BSCW Shock Buffet Case Summary

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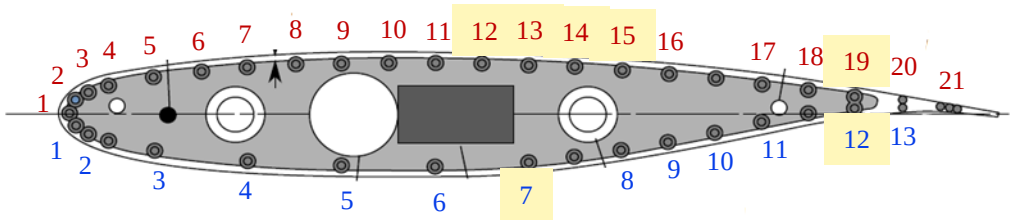
Case Description

- BSCW tested in TDT on Oscillating Turn Table (held at constant angle of attack) with splitter plate
- Mach 0.8, Q=170 psf, AoA=5°, Re=4 x 10^6
- RMS pressure values indicate high amplitude oscillation near shock region (pressure port 12–13)
- Does shock buffet impact flutter onset?



BSCW 60% Chord Pressure taps

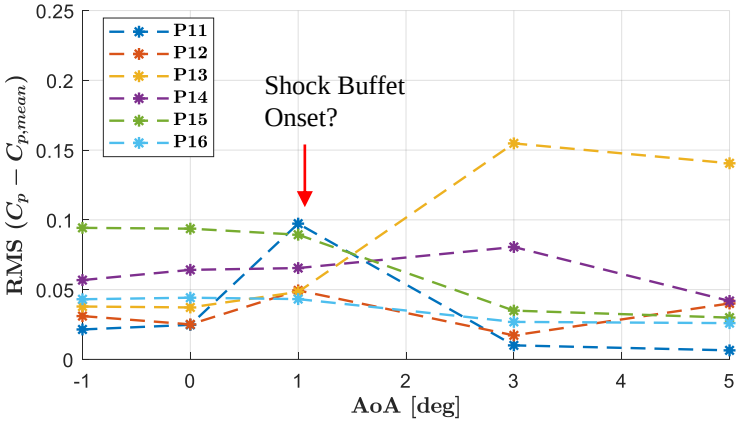
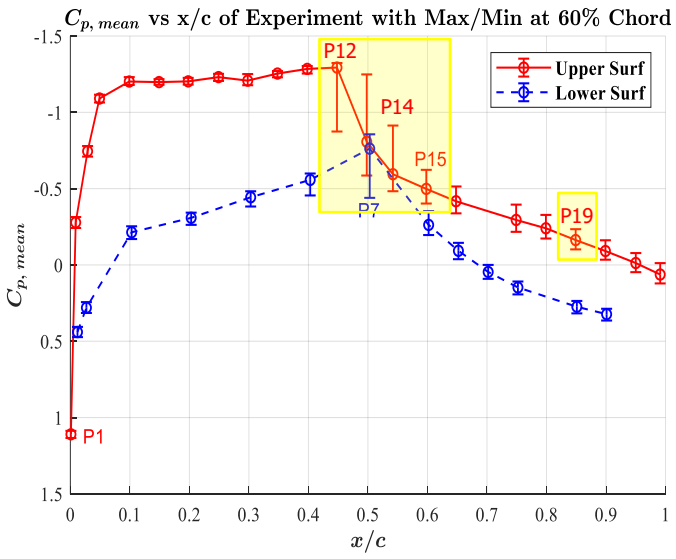


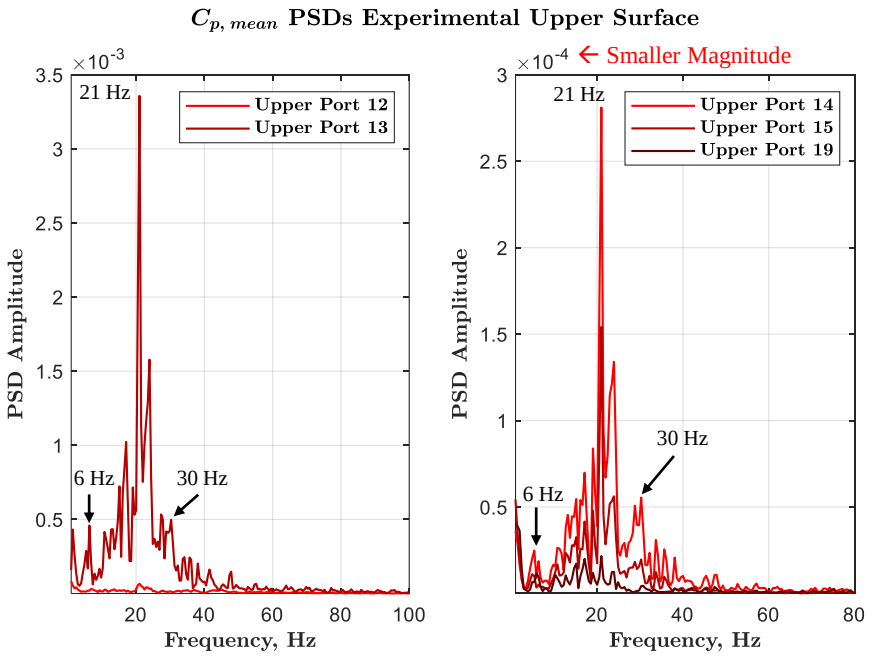
Table 3. Pressure orifice locations, x/c, at 60% span

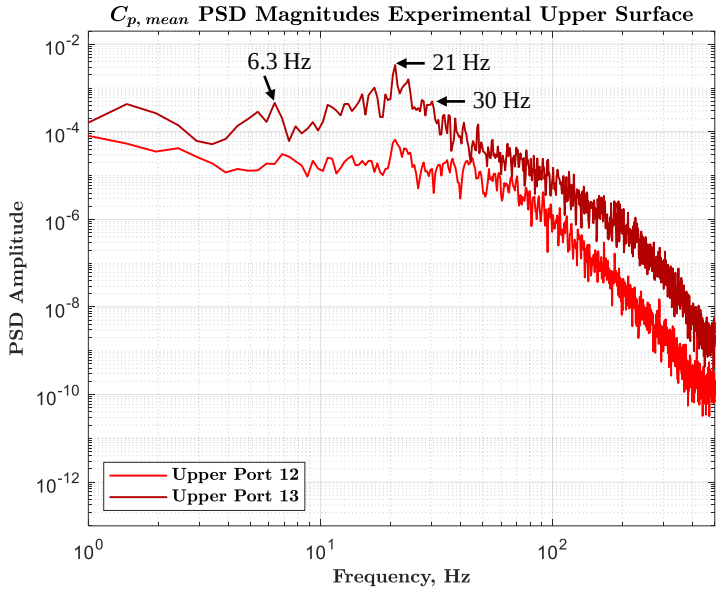
Upper		Lower	
Transducer #	x/c	Transducer #	x/c
1	0	1	0.012
2	0.009	2	0.027
3	0.023	3	0.103
4	0.049	4	0.203
5	0.099	5	0.303
6	0.149	6	0.403
7	0.198	7	0.503
8	0.249	8	0.602
9	0.298	9	0.652
10	0.348	10	0.702
11	0.398	11	0.752
12	0.448	12	0.851
13	0.498	13	0.901
14	0.542		
15	0.598		
16	0.648		
17	0.749		
18	0.799		
19	0.849		
20	0.899		
21	0.95		
22	1		

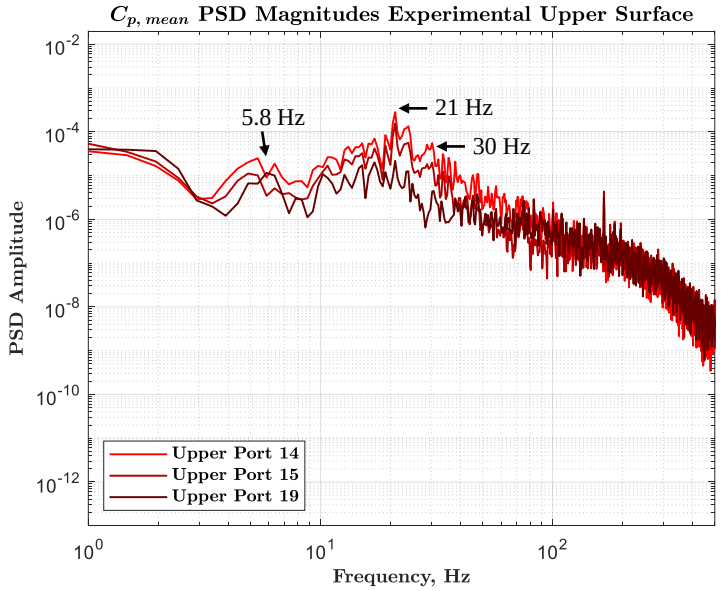
Experimental Data: Regions of Interest on Upper Surface

- PSD results of upper surface pressure data in shock vicinity show peak frequencies near 6, 21, and 30 Hz. Data sampled at 1000 samp/sec. (Note: flutter frequency ≈ 5 Hz)
- Upper port 19 within assumed separation region also shows similar peak frequencies near 6, 21, and 30 Hz.



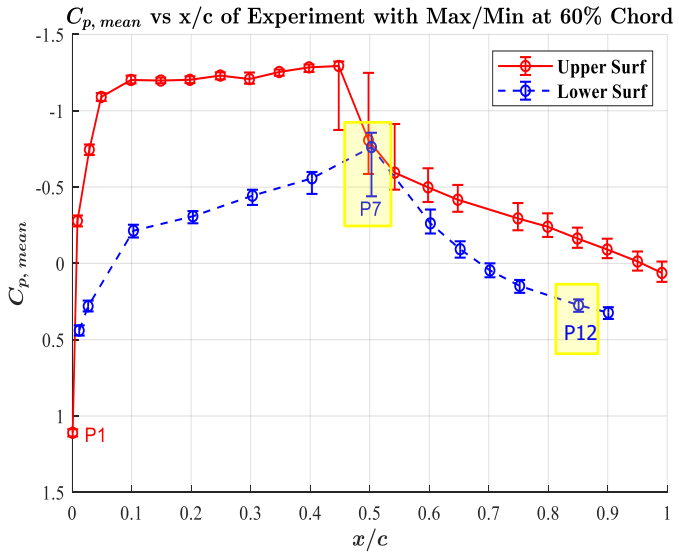


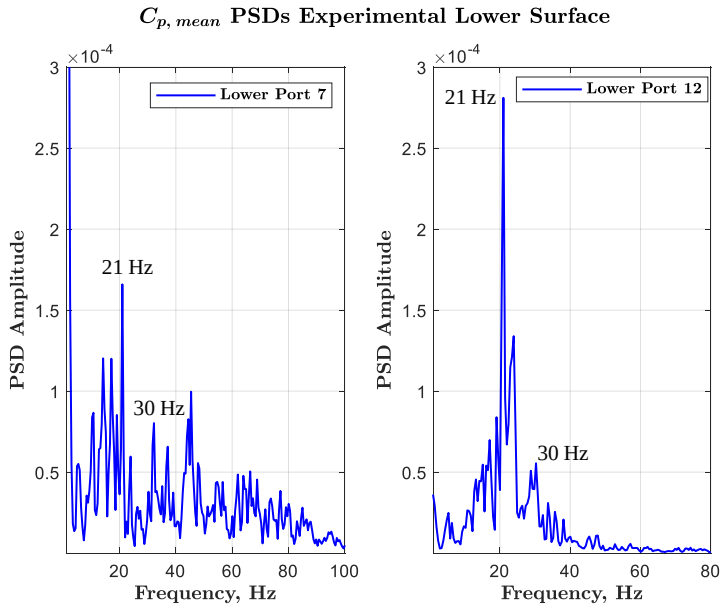


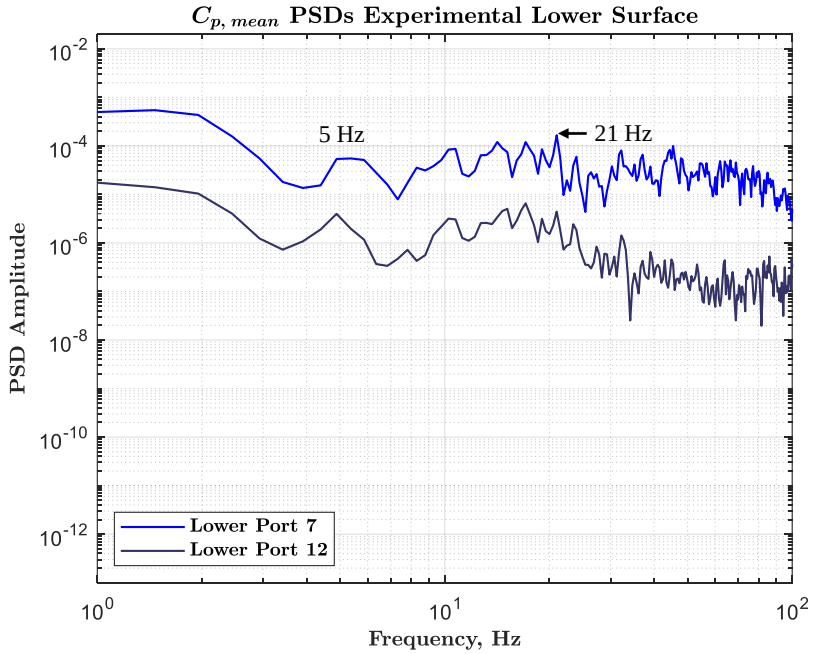


Experimental Data: Regions of Interest Lower Surface

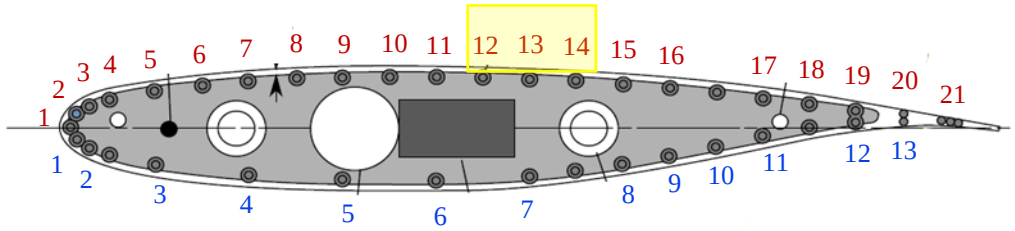
- Single sensor in lower shock region selected (Lower port 7)
- PSD solutions reveal peak near 5, 21 and 30 Hz
- Point near trailing edge (Lower port 12) also selected

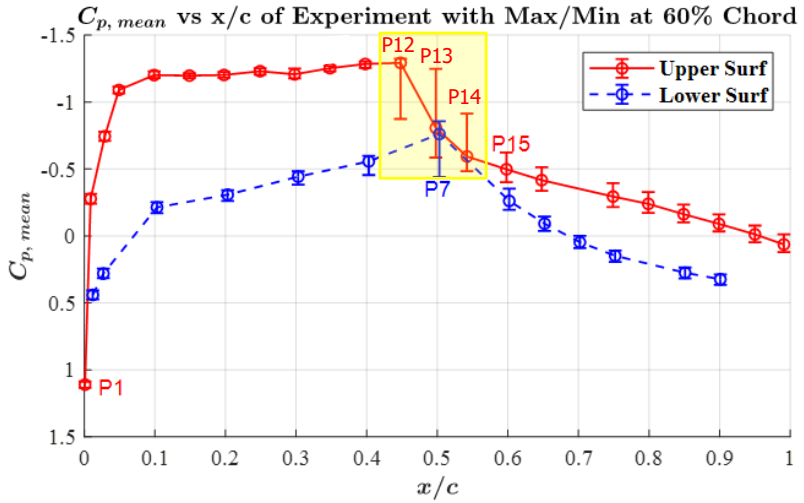


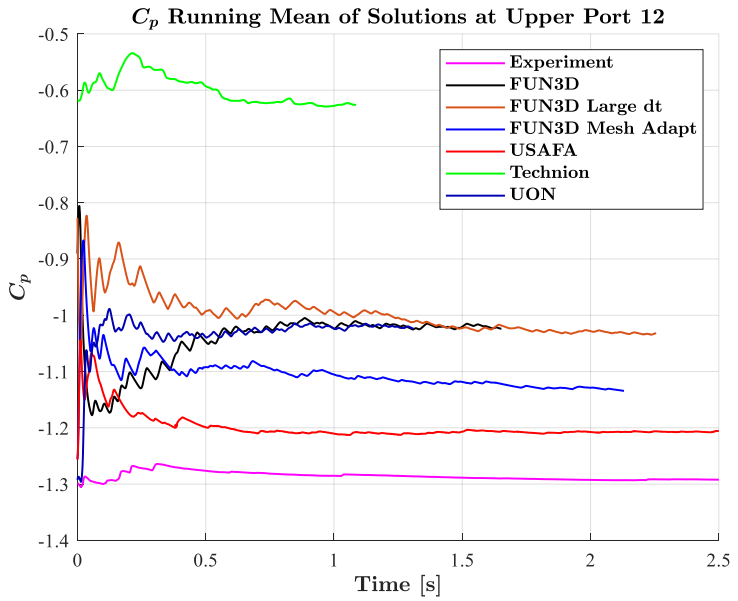


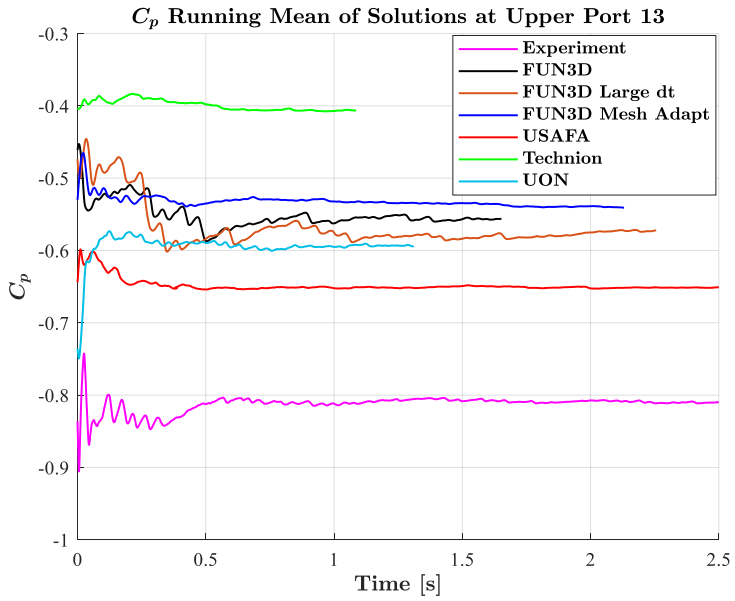


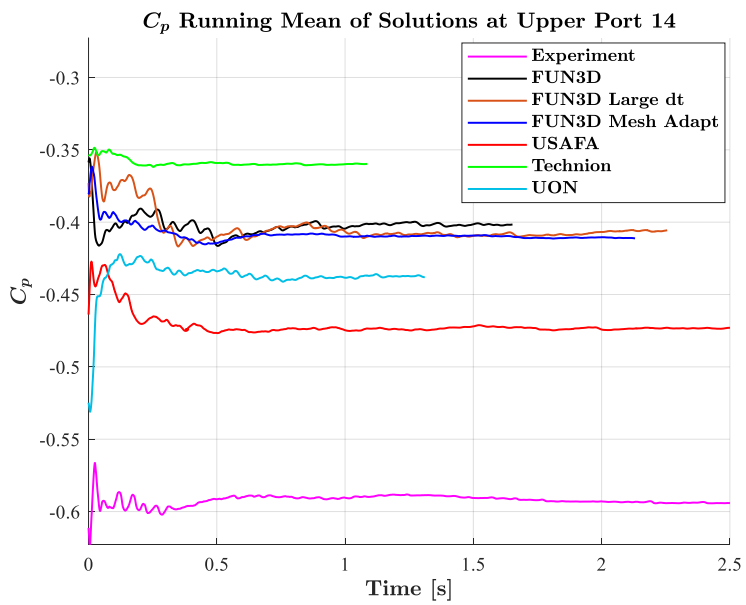
Experimental (in pink) and Computational Running Mean Comparisons Upper Ports 12-14



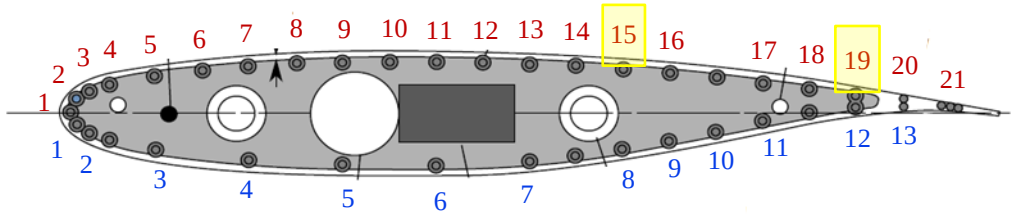


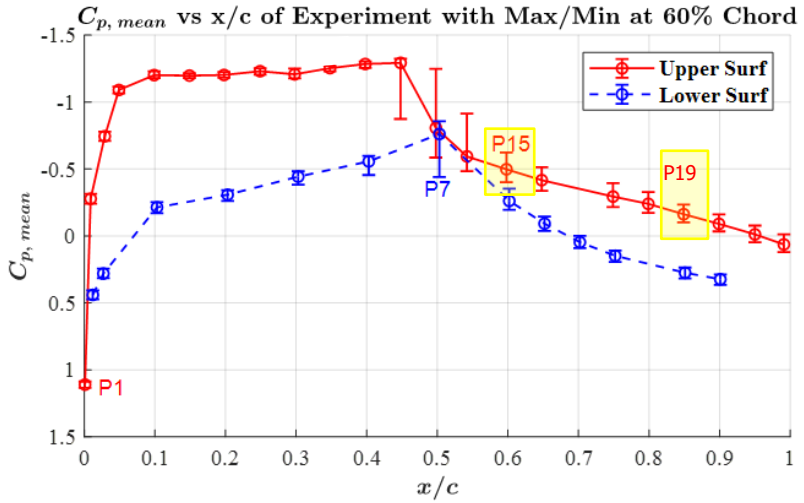


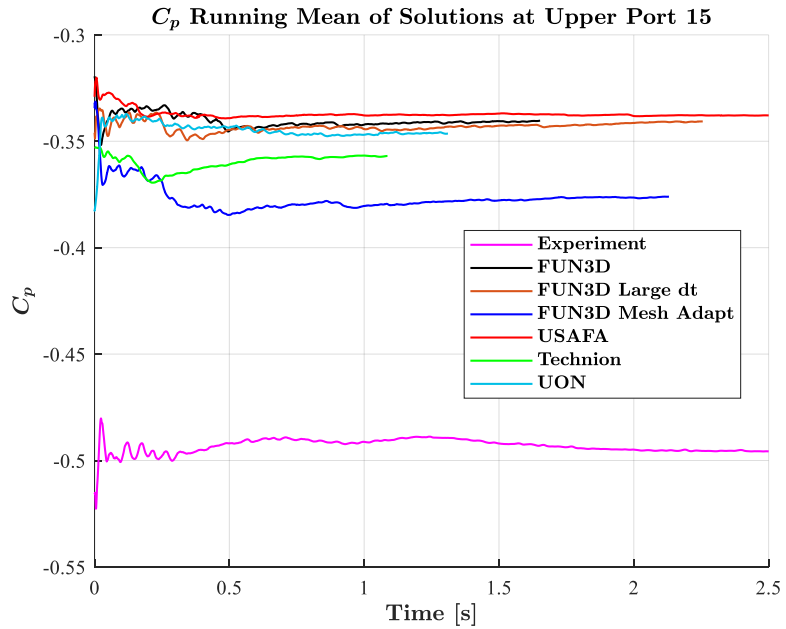


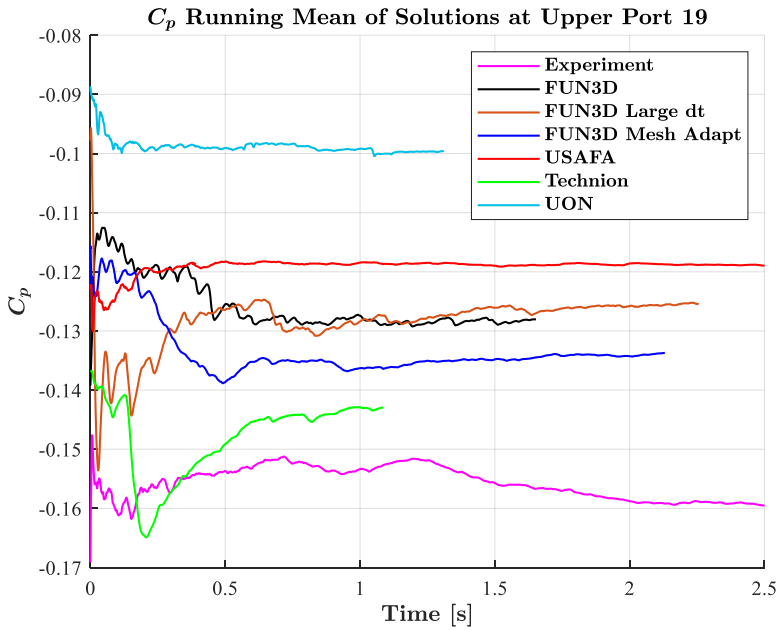


Experimental (in pink) and Computational Running Mean Comparisons Upper Ports 15, 19

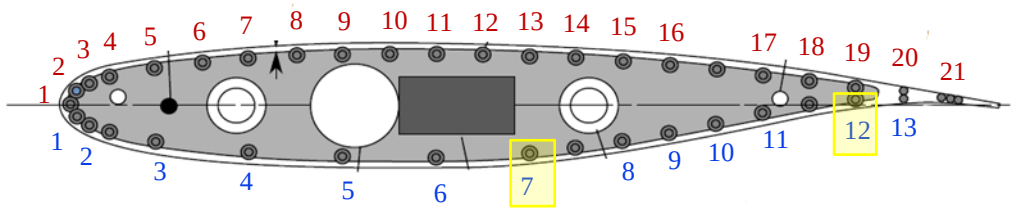


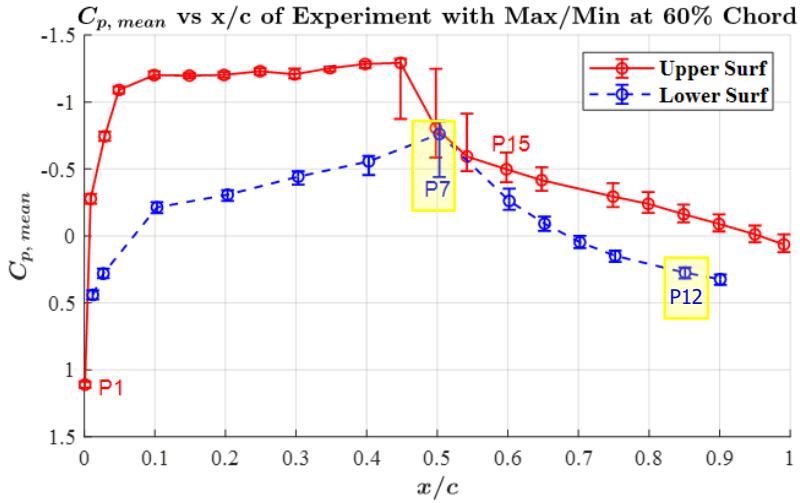


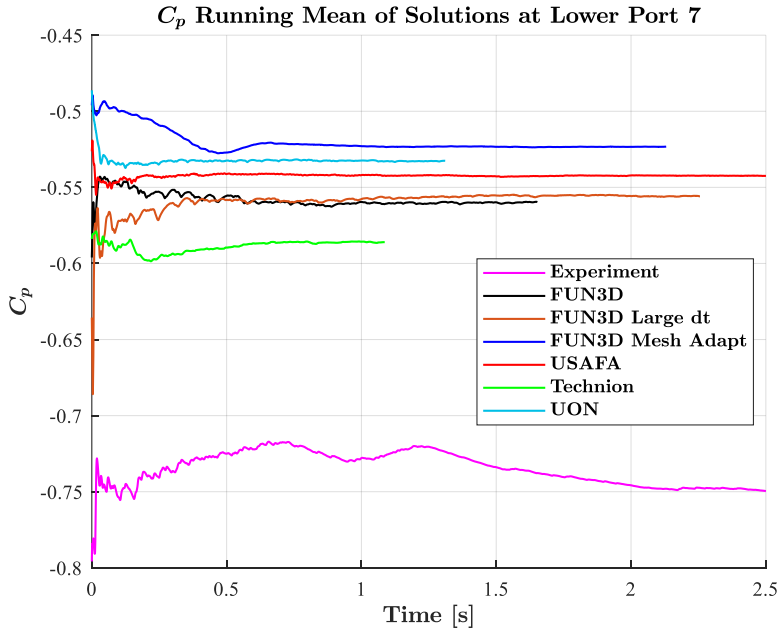


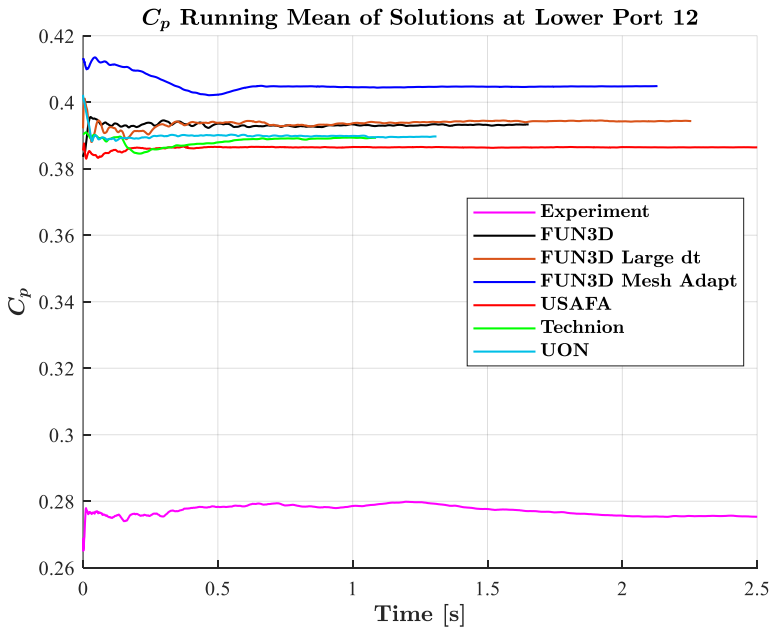


Experimental (in pink) and Computational Running Mean Comparisons Lower Ports 7, 12



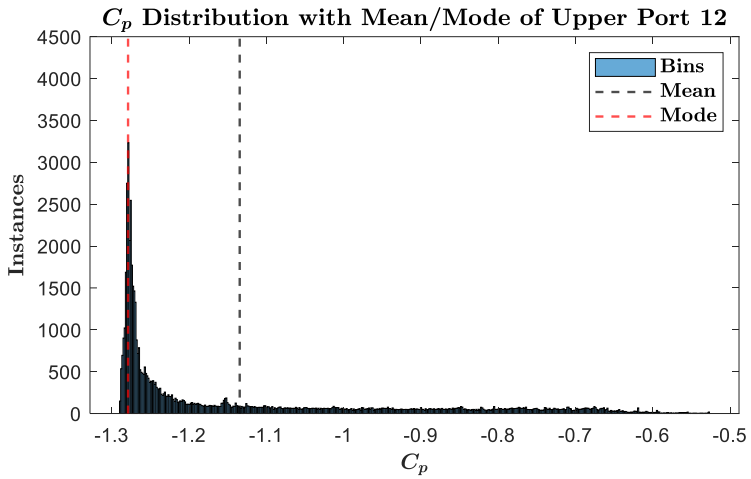


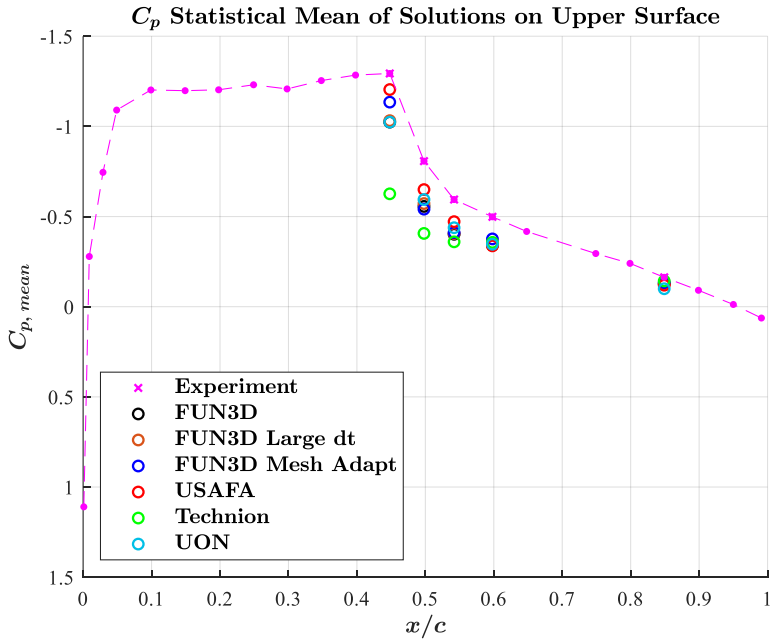


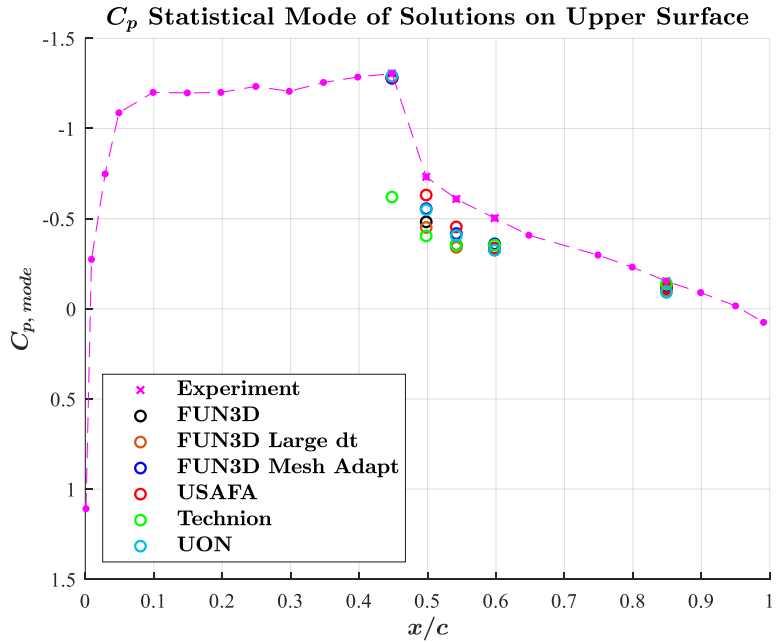


Pressure Comparisons Upper Surface

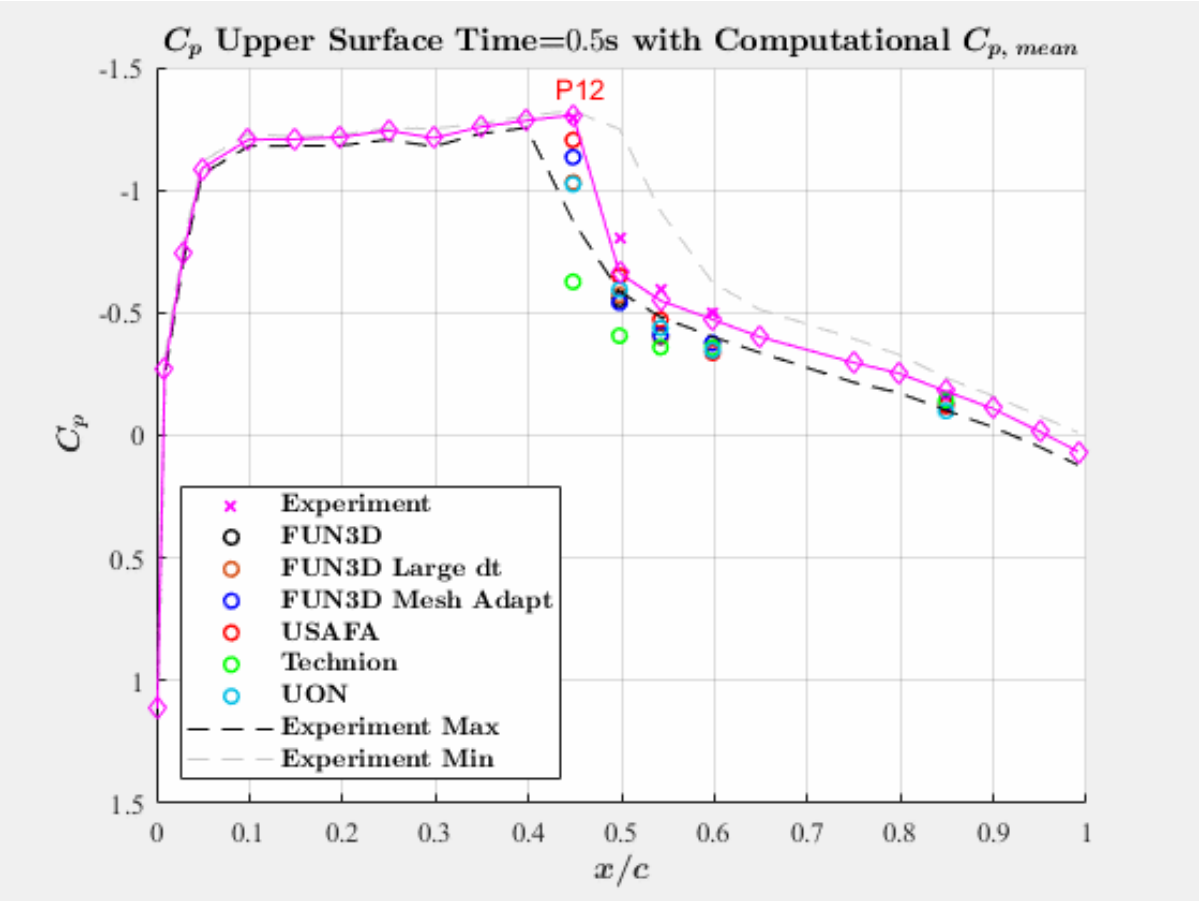
- Histogram indicates statistical mode may be more accurate in comparing steady pressure results near shock region
- Shock location may be stronger/slightly more aft in computational results





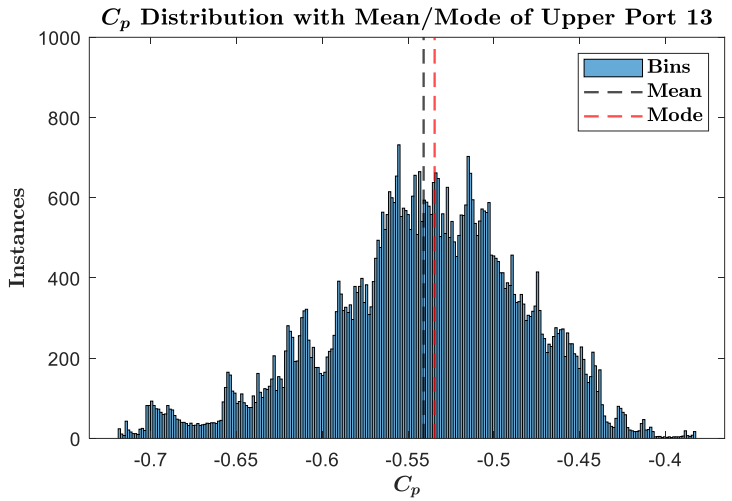


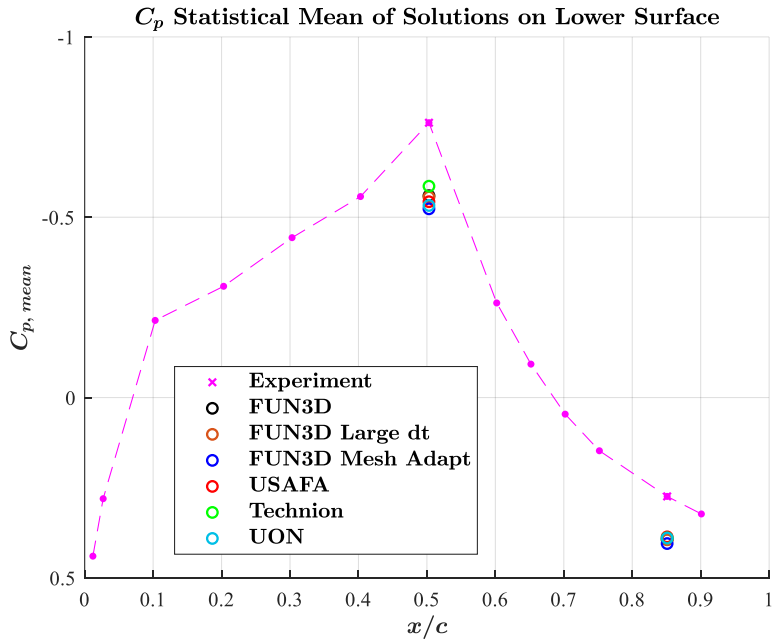
Upper Surface Experimental Pressure Motion and Mean Computational values

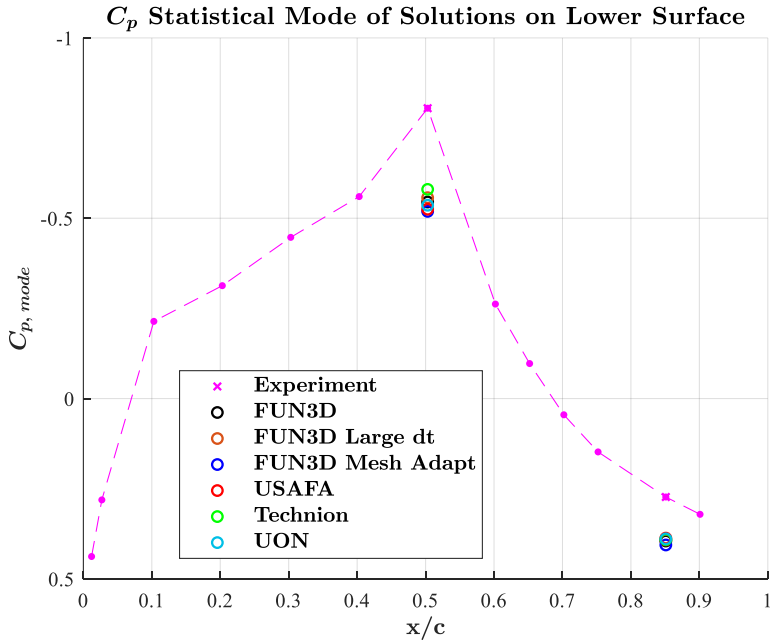


Pressure Comparisons Lower Surface

- Less data skew near lower surface shock (weaker shock)
- Shock location and strength unclear with lower surface points of interest
- Underprediction of C_p in all computational results

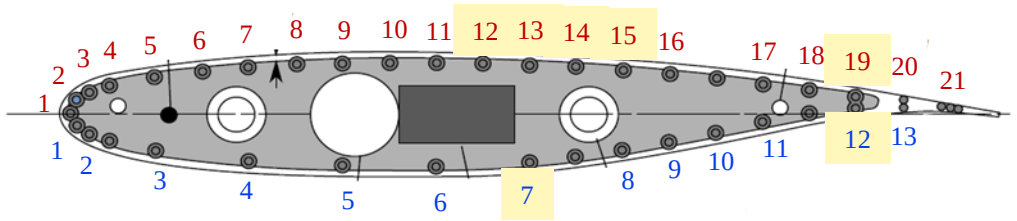






Spectral Comparisons: Individual Pressure Ports

PSD Matlab pwelch settings will be added here !!!



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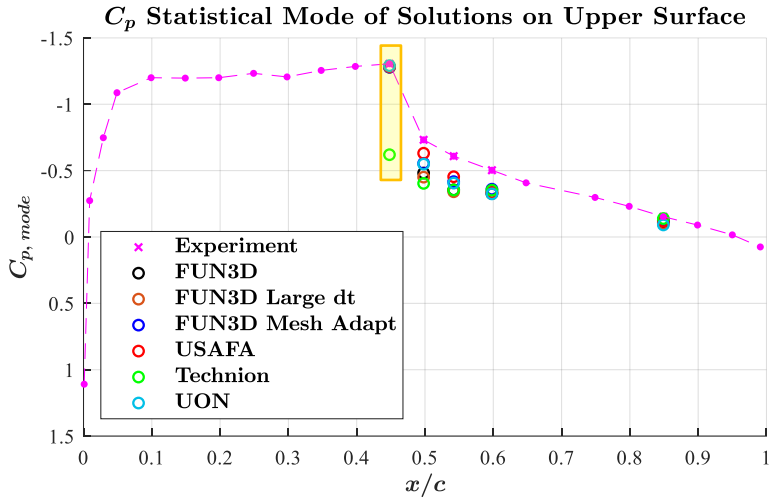
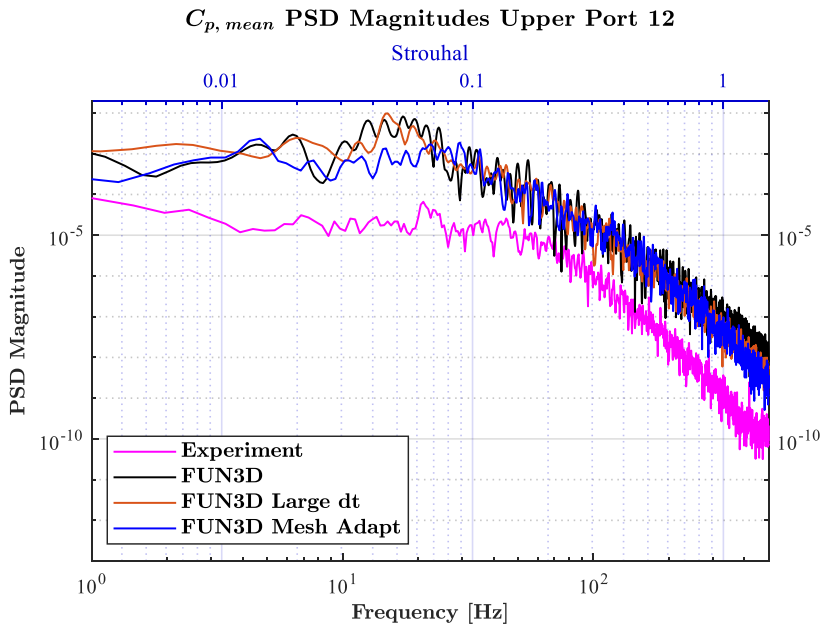
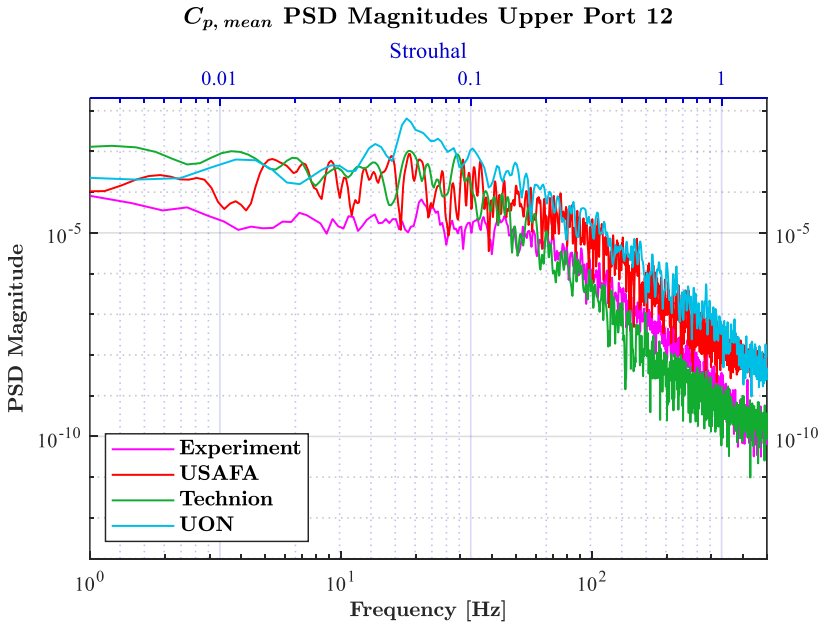
22	1		

Spectral Comparisons of C_p Upper Port 12

- All computational results reveal higher magnitudes but similar peak frequencies, particularly near 21 Hz
- FUN3D Mesh adaptation results closest to experiment in terms of PSD magnitude
- UON results closest in terms of peak frequencies

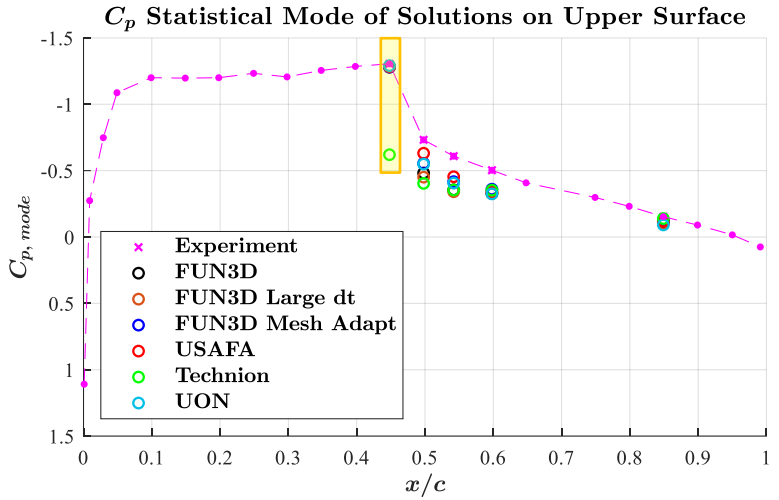


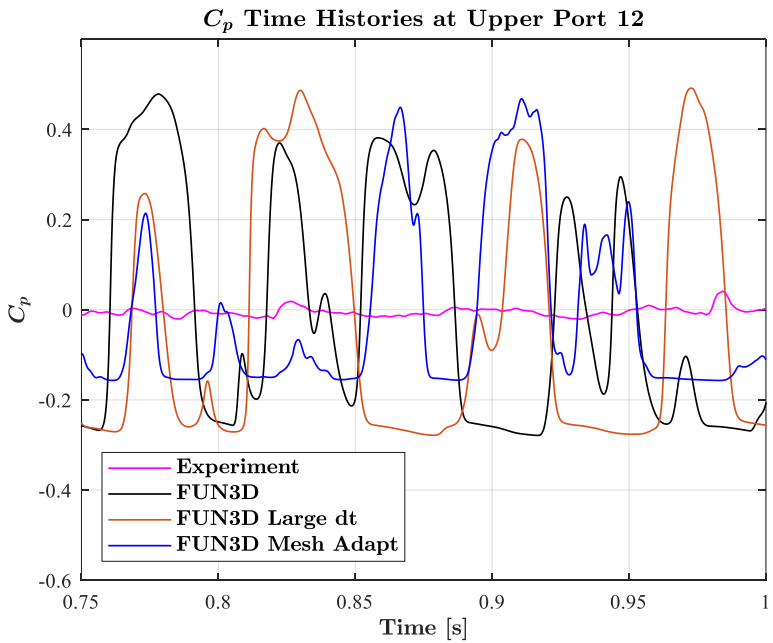


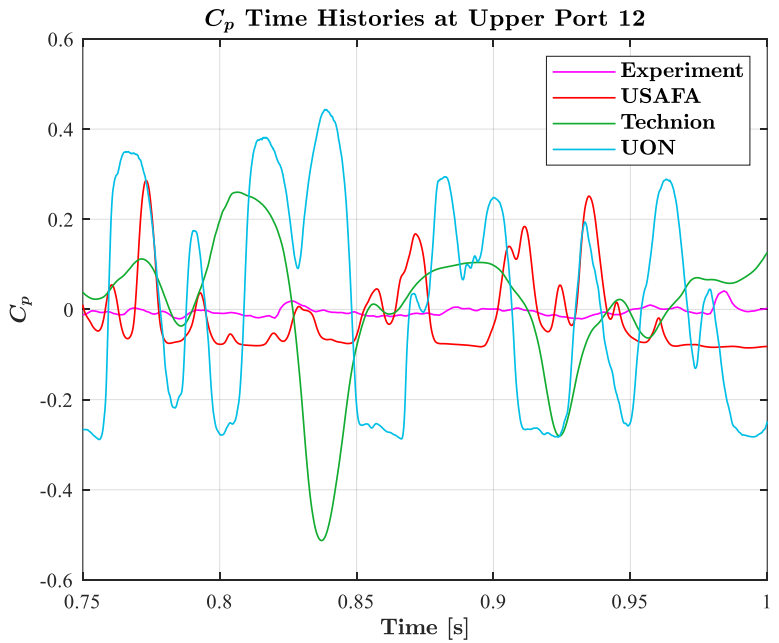


Time Histories of C_p Upper Port 12

- Difference in magnitudes indicate shock location and/or lambda shock structure or strength may vary between experimental and computational results
- Computational oscillation magnitudes much higher than experimental

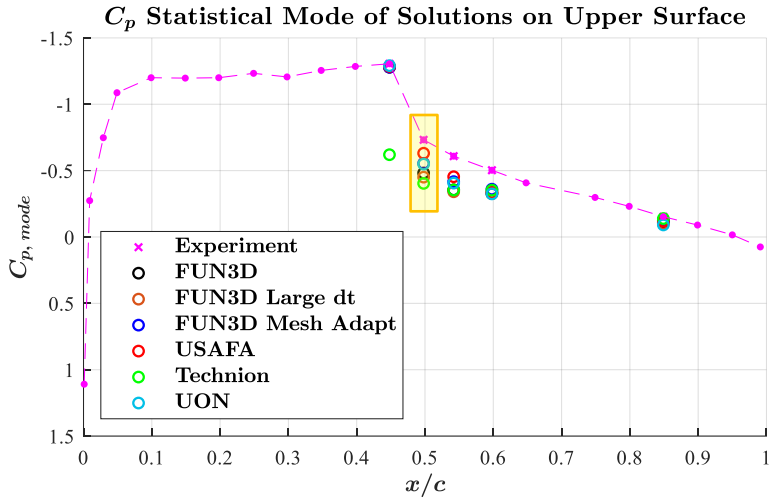


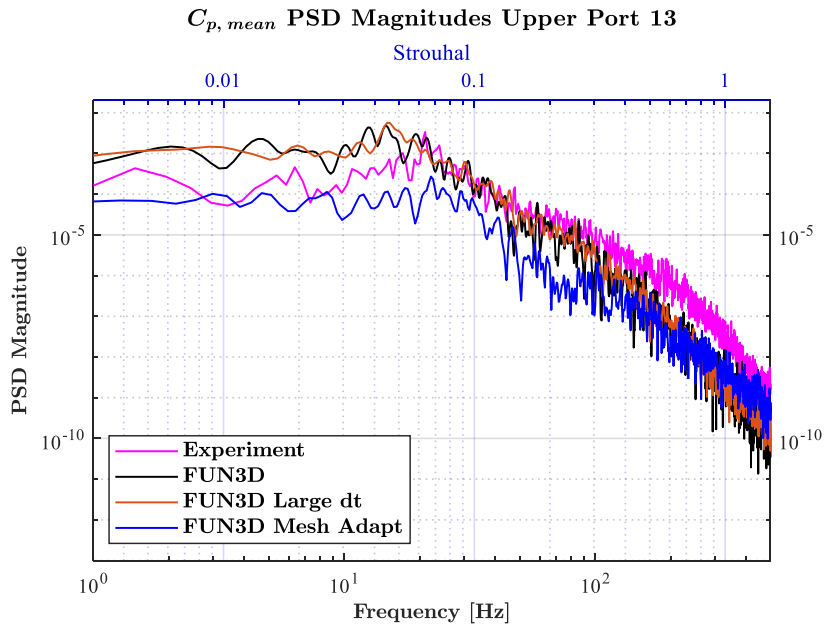


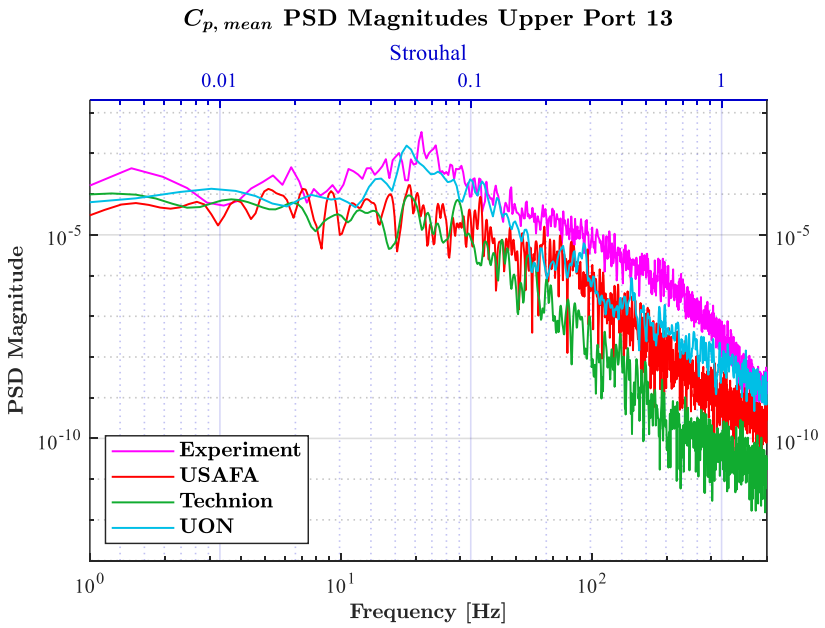


Spectral Comparisons of C_p Upper Port 13

- All computational results reveal lower or similar magnitudes with similar peak frequencies, particularly near 21 Hz
- UON results closest to experiment in terms of both PSD magnitude, shape and peak frequencies

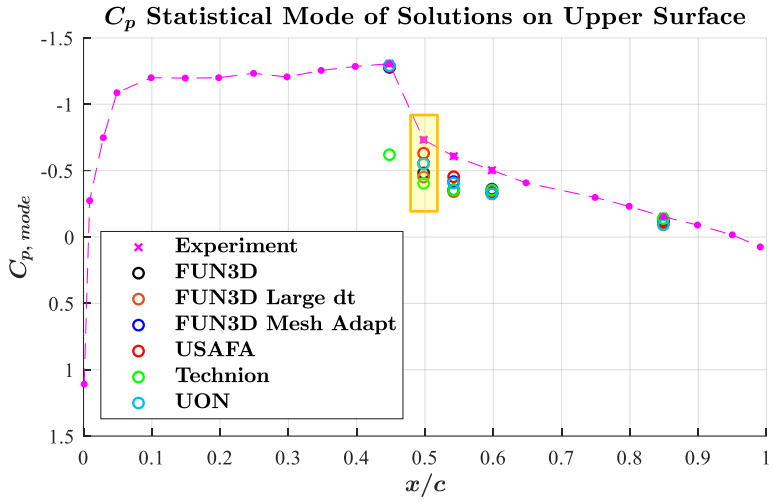


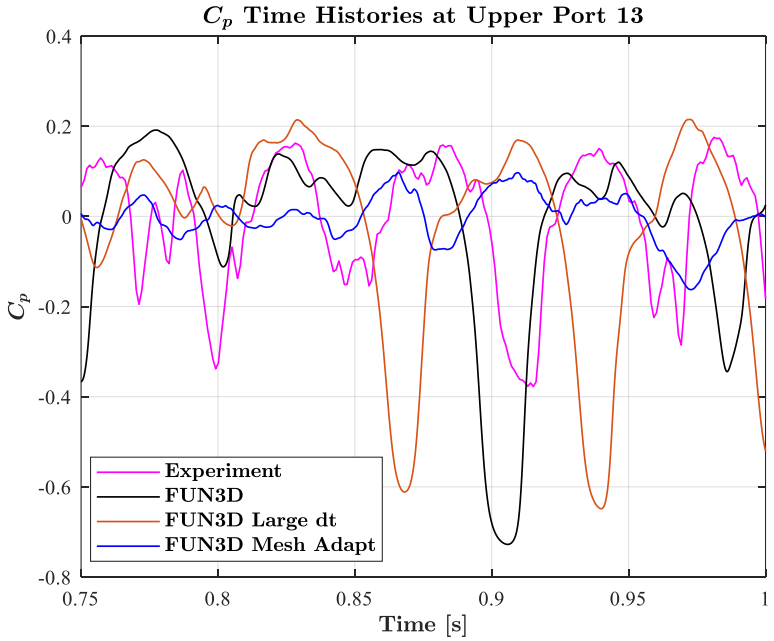


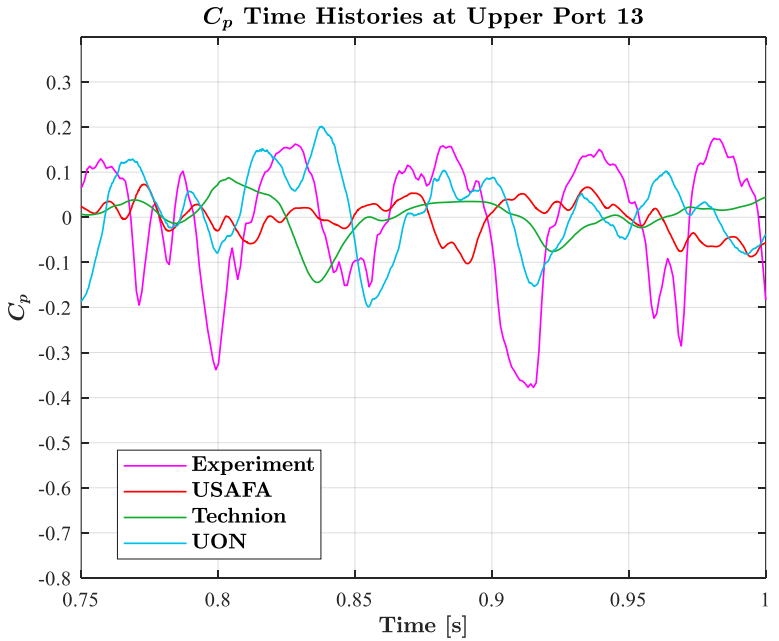


Time Histories of C_p Upper Port 13

- Difference in magnitudes indicate shock location and/or lambda shock structure or strength may vary between experimental and computational results
- Computational oscillation magnitudes mostly lower than experimental

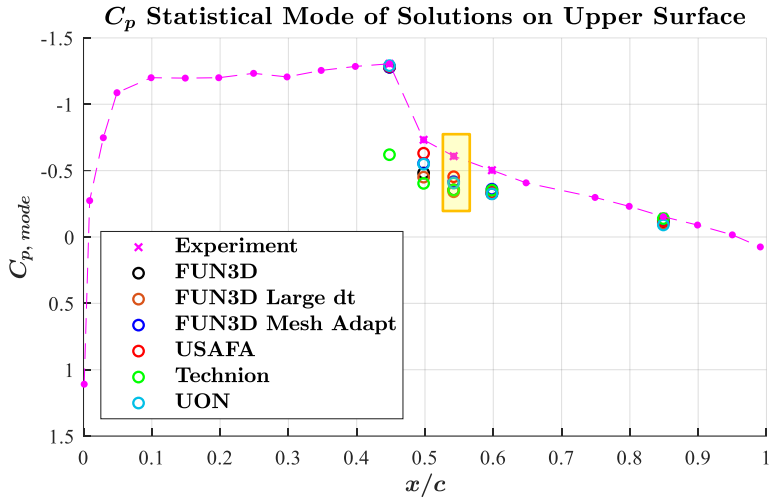


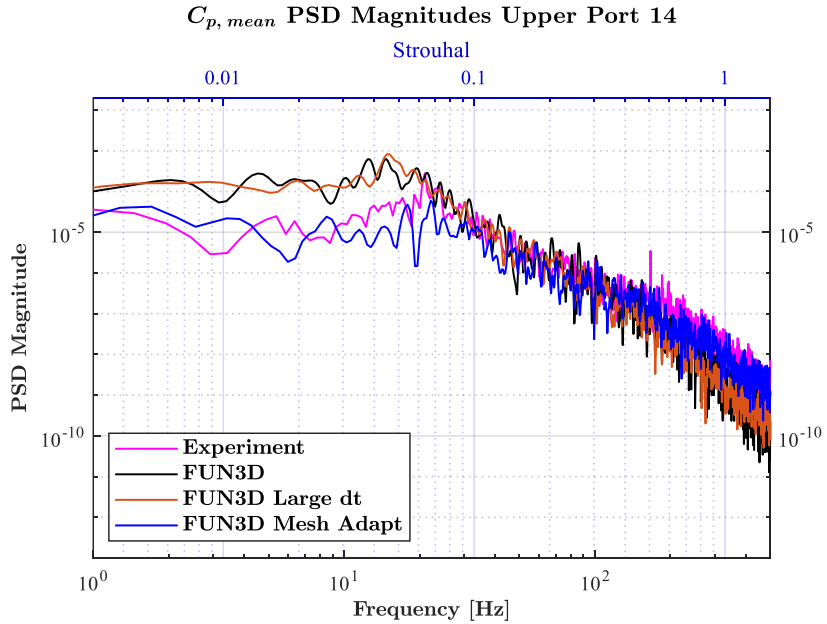


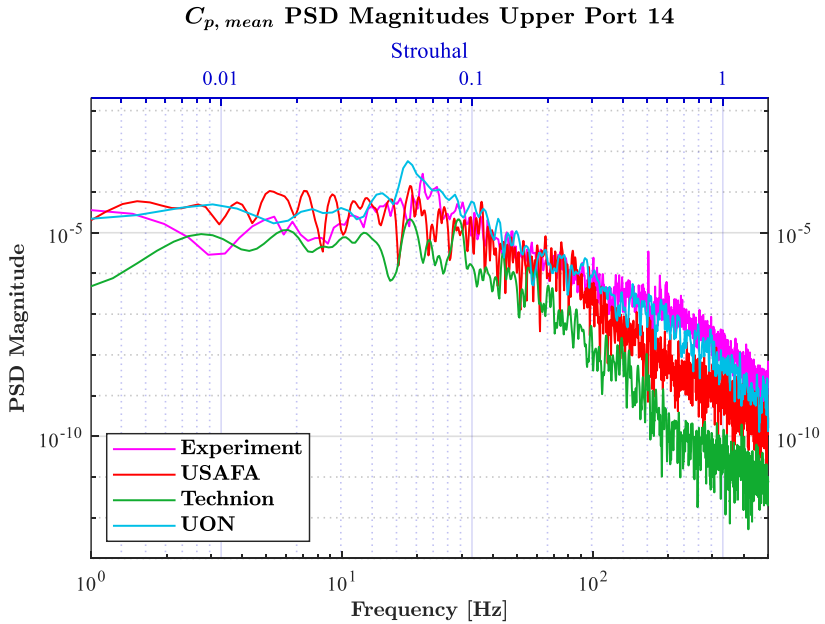


Spectral Comparisons of C_p Upper Port 14

- All computational results show lower or similar magnitudes with similar peak frequencies, particularly near 21 Hz
- FUN3D mesh adaptation results closest in terms of peak frequency results.
- USAFA results closest in terms of PSD shape and magnitude

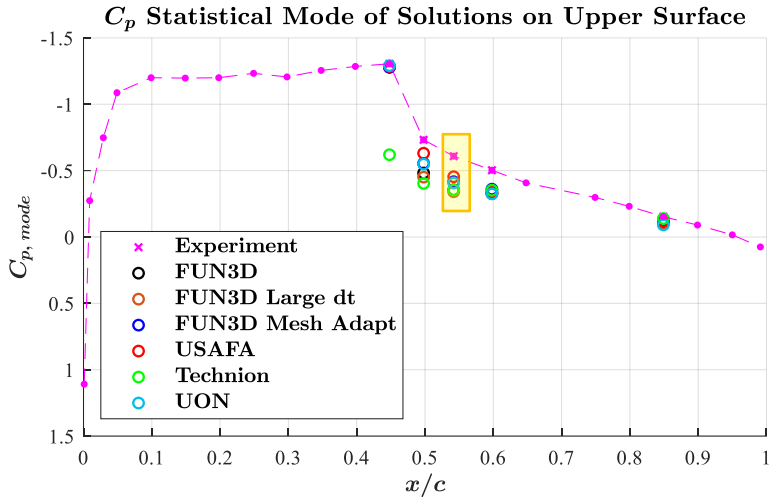


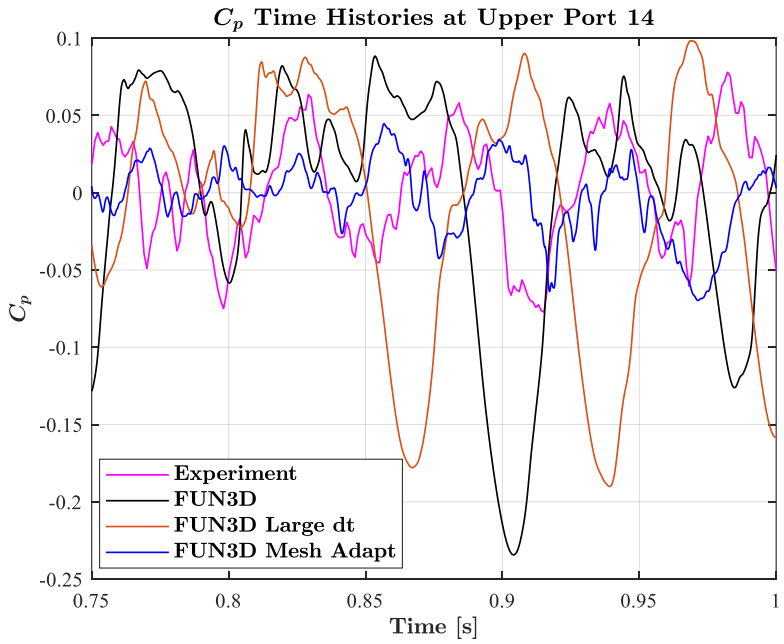


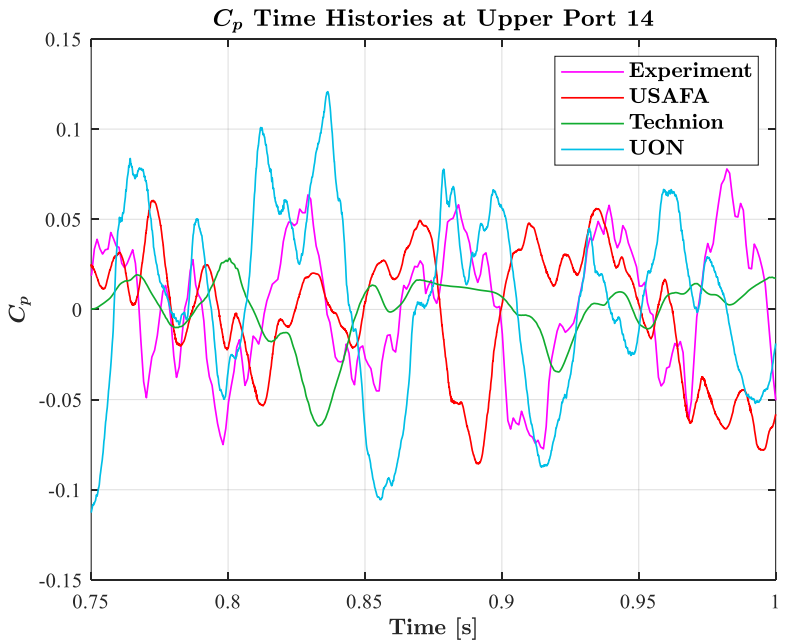


Time Histories of C_p Upper Port 14

- Experimental and computational oscillations comparable

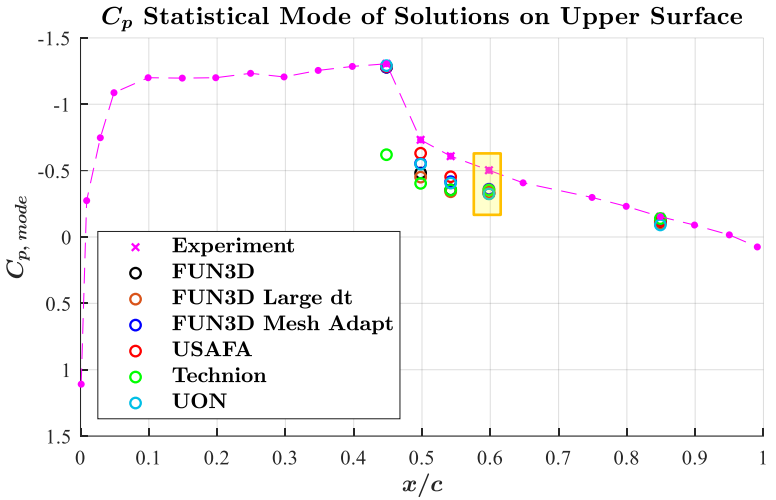


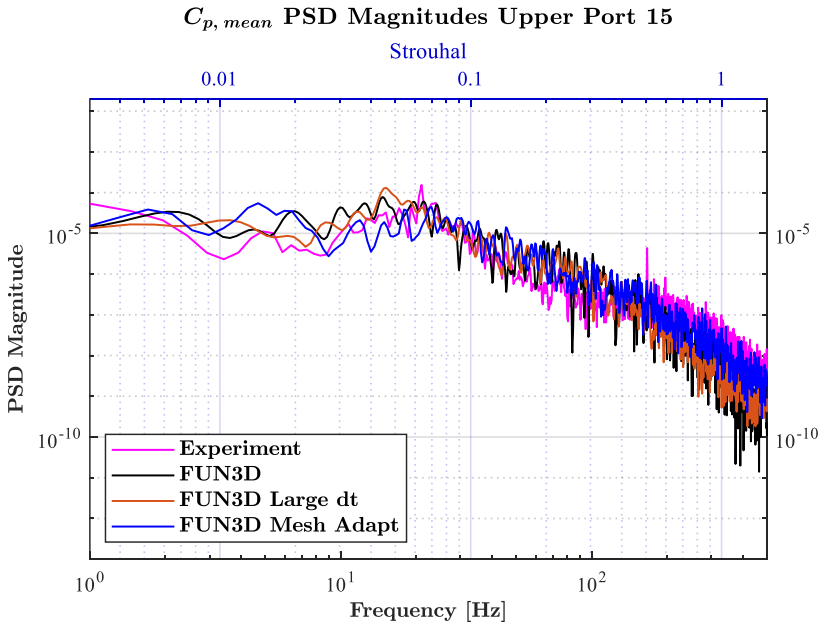


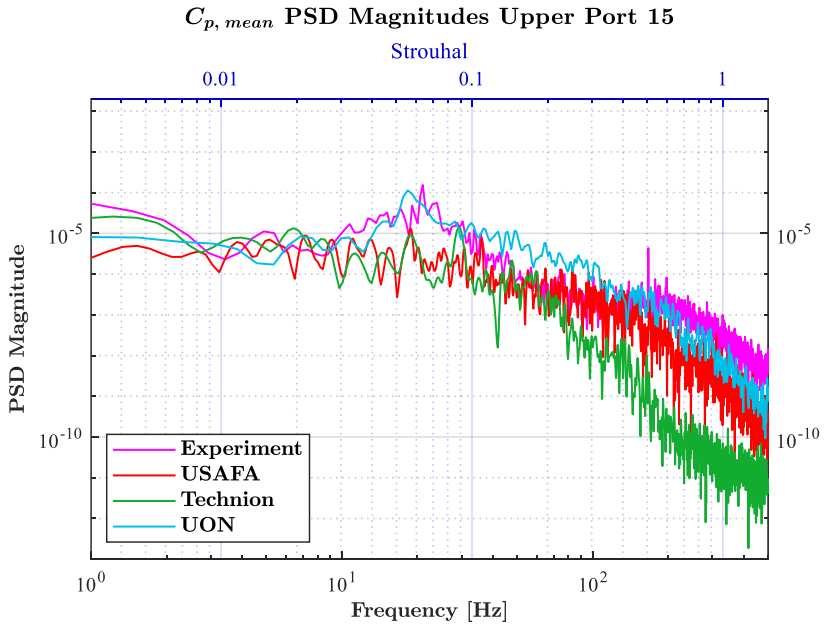


Spectral Comparisons of C_p Upper Port 15

- All computational results show similar magnitudes as well as similar peak frequencies, particularly near 21 Hz
- All FUN3D and UON results match experimental results well

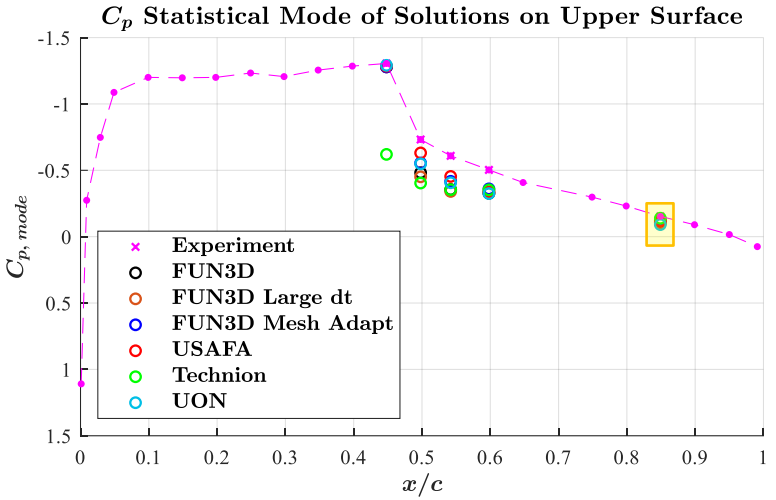


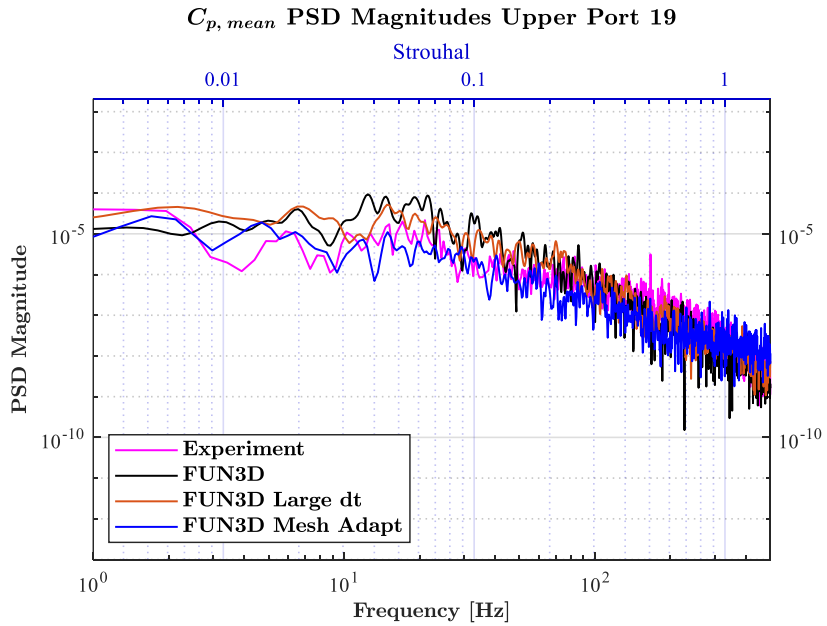


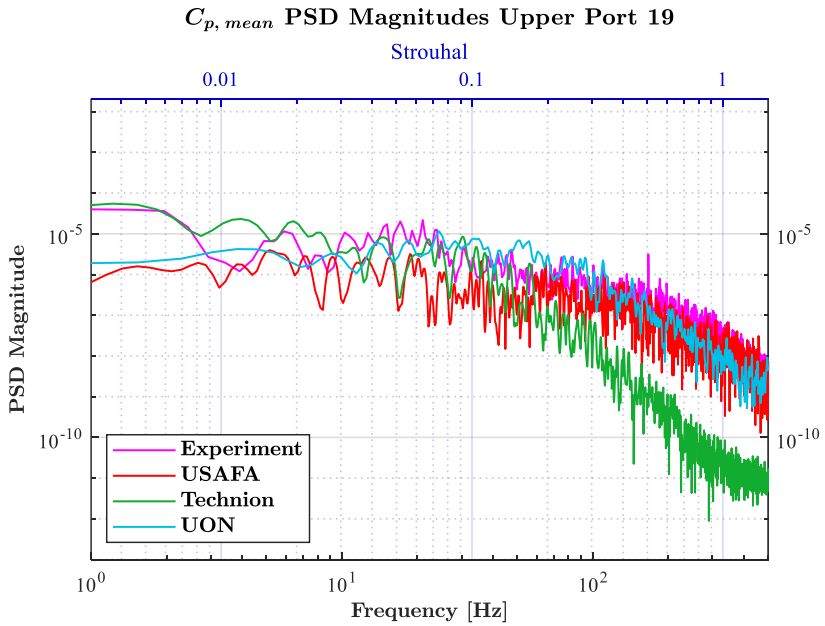


Spectral Comparisons of C_p Upper Port 19

- All computational results show similar magnitudes as well as similar peak frequencies, particularly near 21 Hz
- FUN3D with large dt and UON results match experimental results well

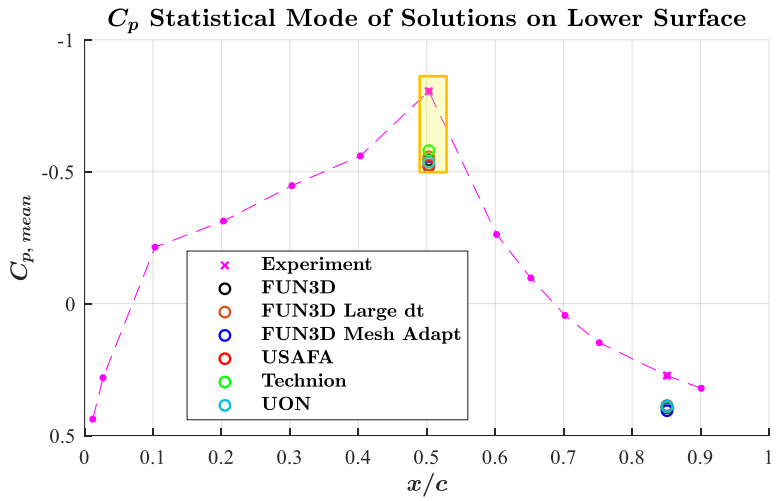


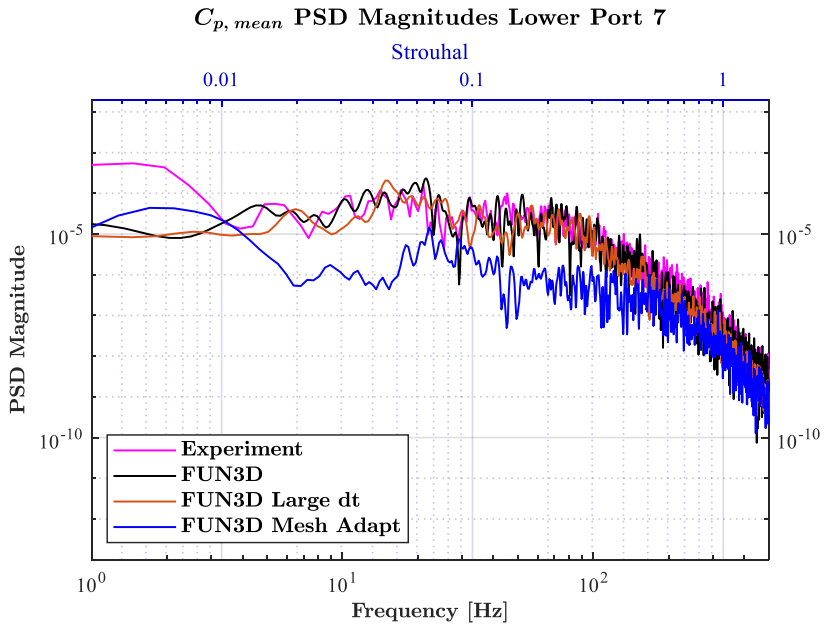


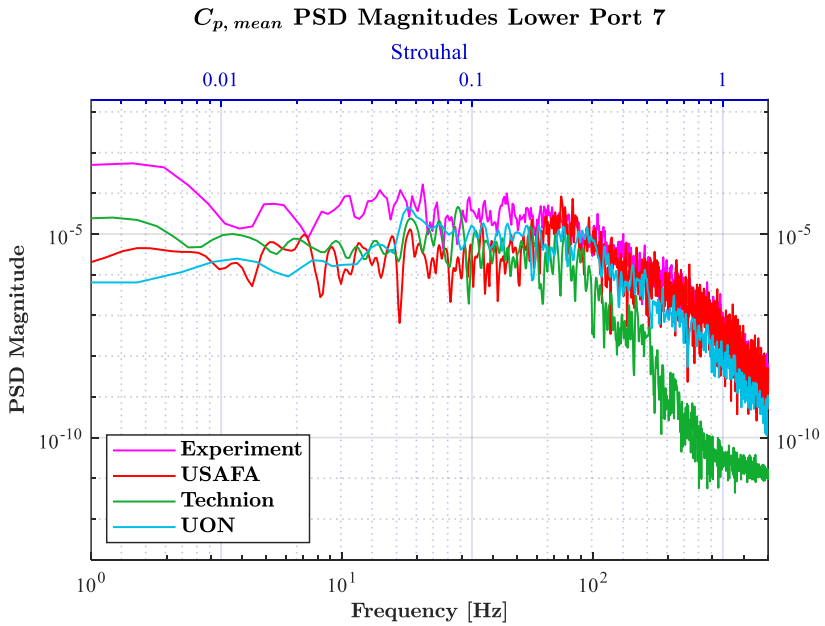


Spectral Comparisons of C_p Lower Port 7

- All computational results show similar magnitudes (with the exception of FUN3D mesh adaptation) and similar peak frequencies
- FUN3D results closest to experimental.

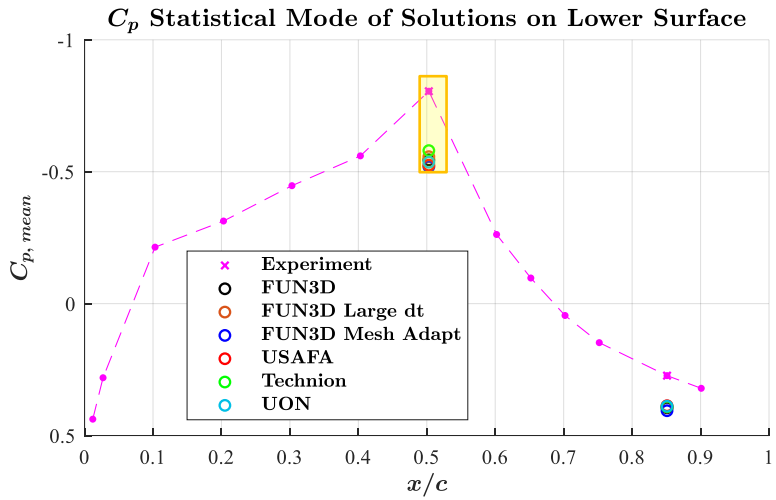


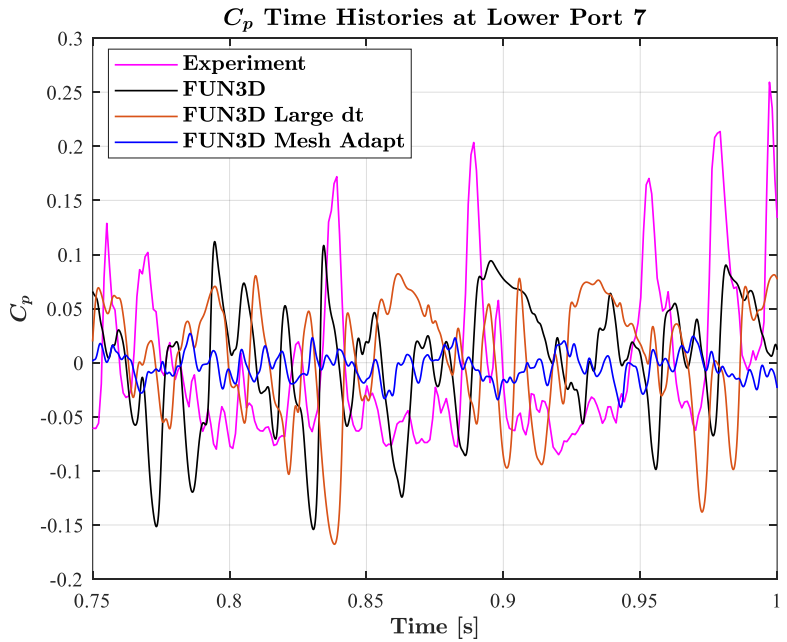


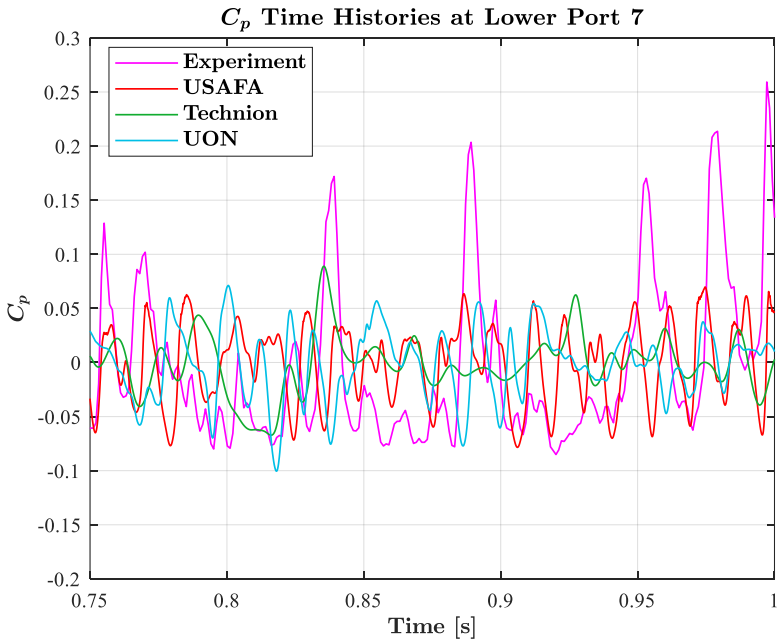


Time Histories of C_p Lower Port 7

- FUN3D mesh adaptation oscillation magnitudes lower than all other results
- All computational oscillation magnitudes and mean/mode results are comparable with one another, but underpredict experiment

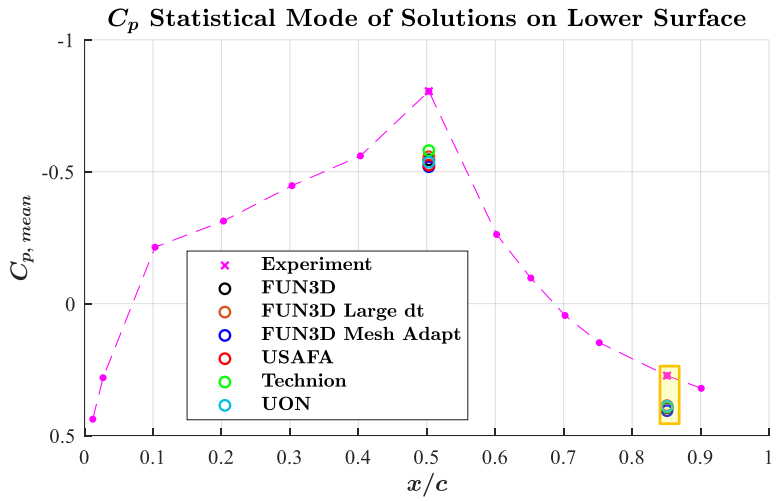


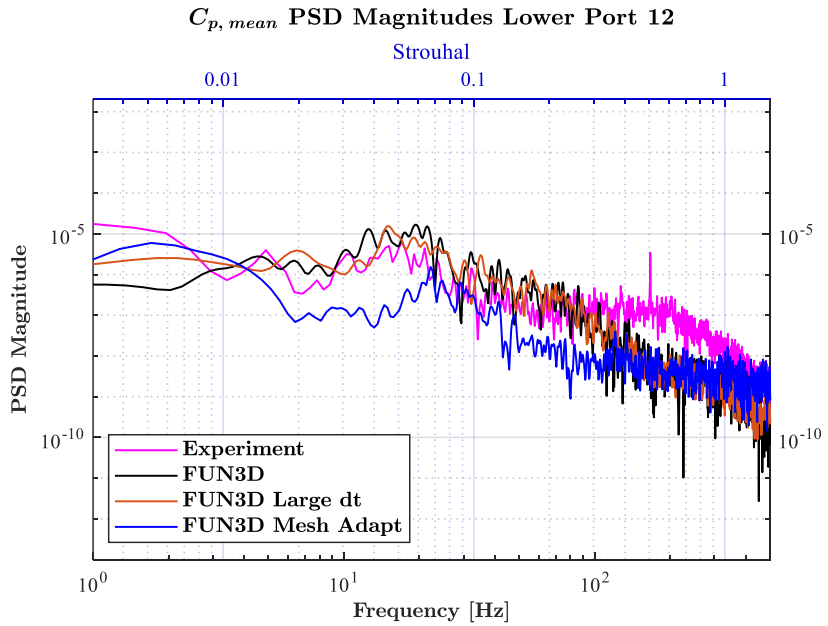


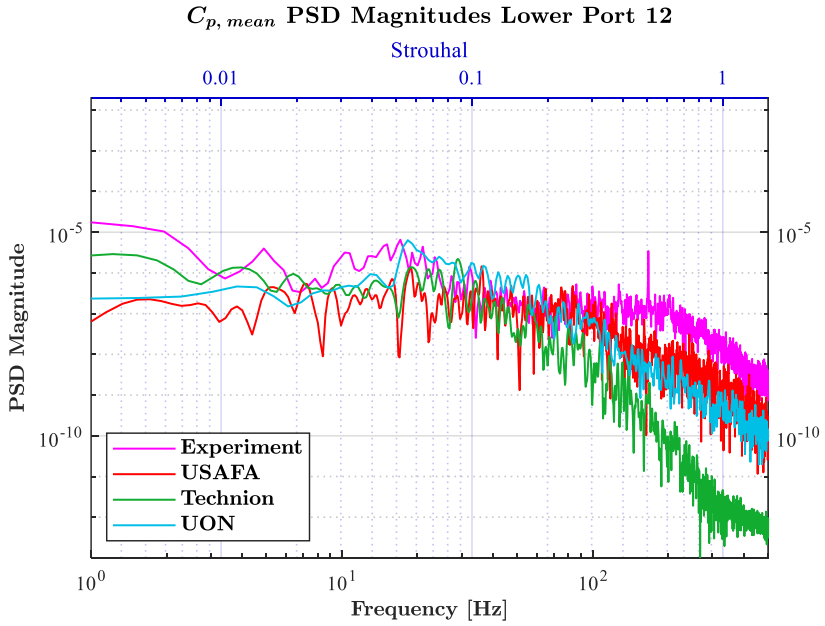


Spectral Comparisons of C_p Lower Port 12

- All computational results reveal similar magnitudes (with the exception of FUN3D mesh adaptation) and similar peak frequencies
- FUN3D results closest to experimental.

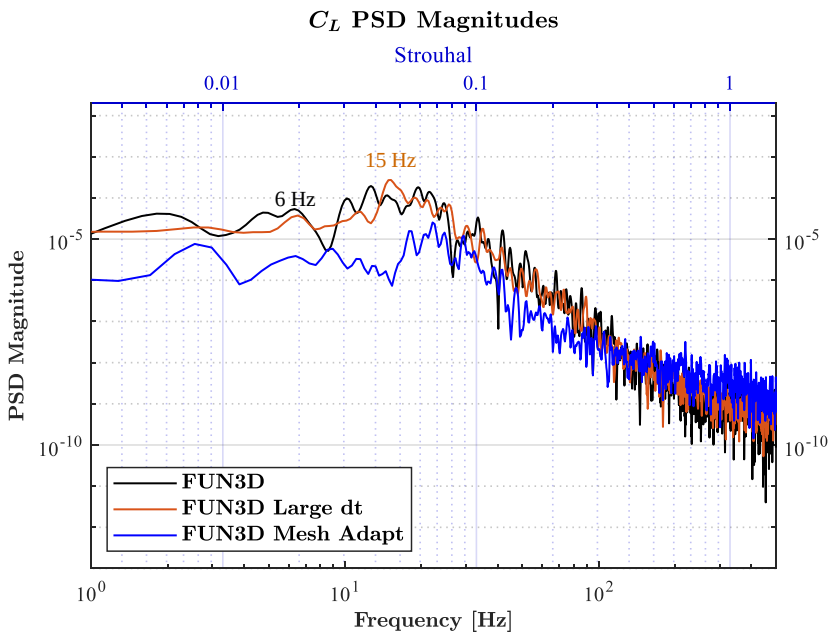


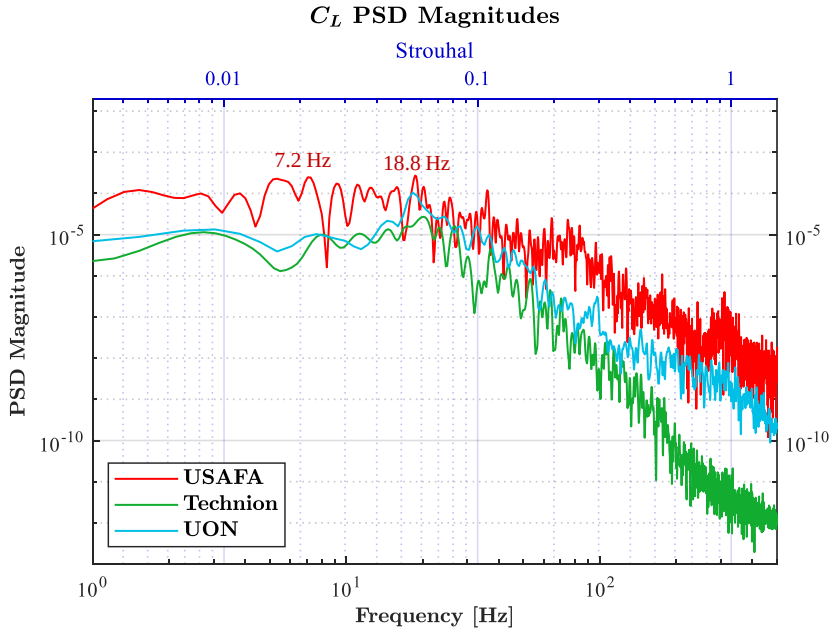




Spectral Comparisons of C_L

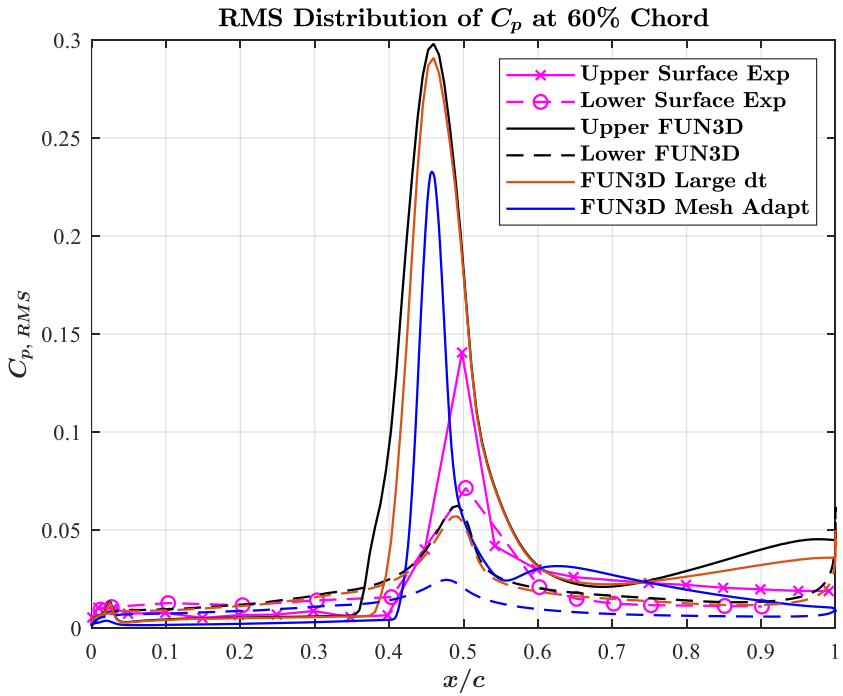
- Computational results only, C_L not measured in experiment
- More variation in low frequency peaks between all results
- FUN3D Mesh Adapt gives peak at 22.5 Hz, FUN3D w/large dt, at 15 Hz while all other solutions give about 18.8 Hz

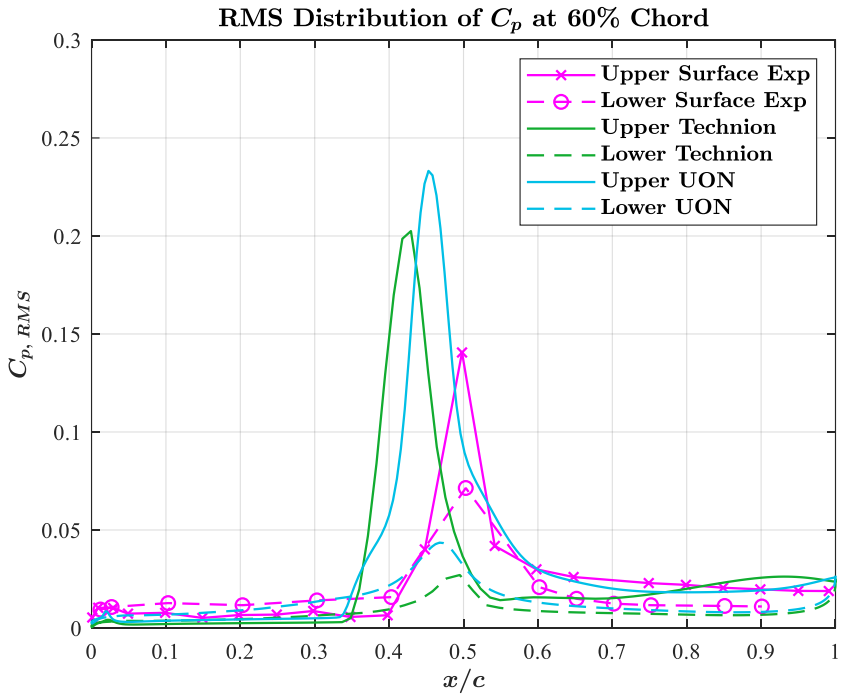




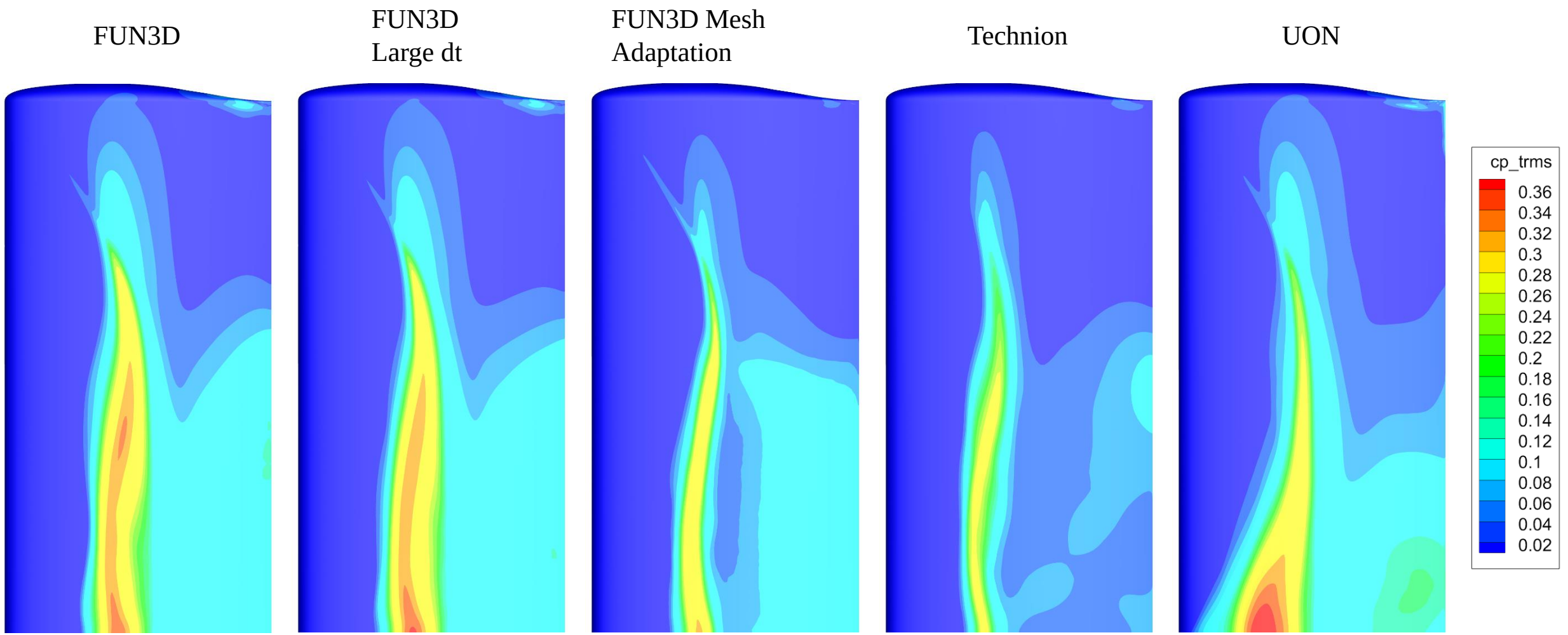
RMS Distribution

- All computational results show rise in $C_{p,RMS}$ forward and higher in magnitude than experimental data on the upper surface. May indicate forward shock location with higher strength
- Lower surface RMS peak positions compare well between computational and experiment. Computational magnitudes lower in magnitude, particularly in Technion andFUN3D mesh adaptation results

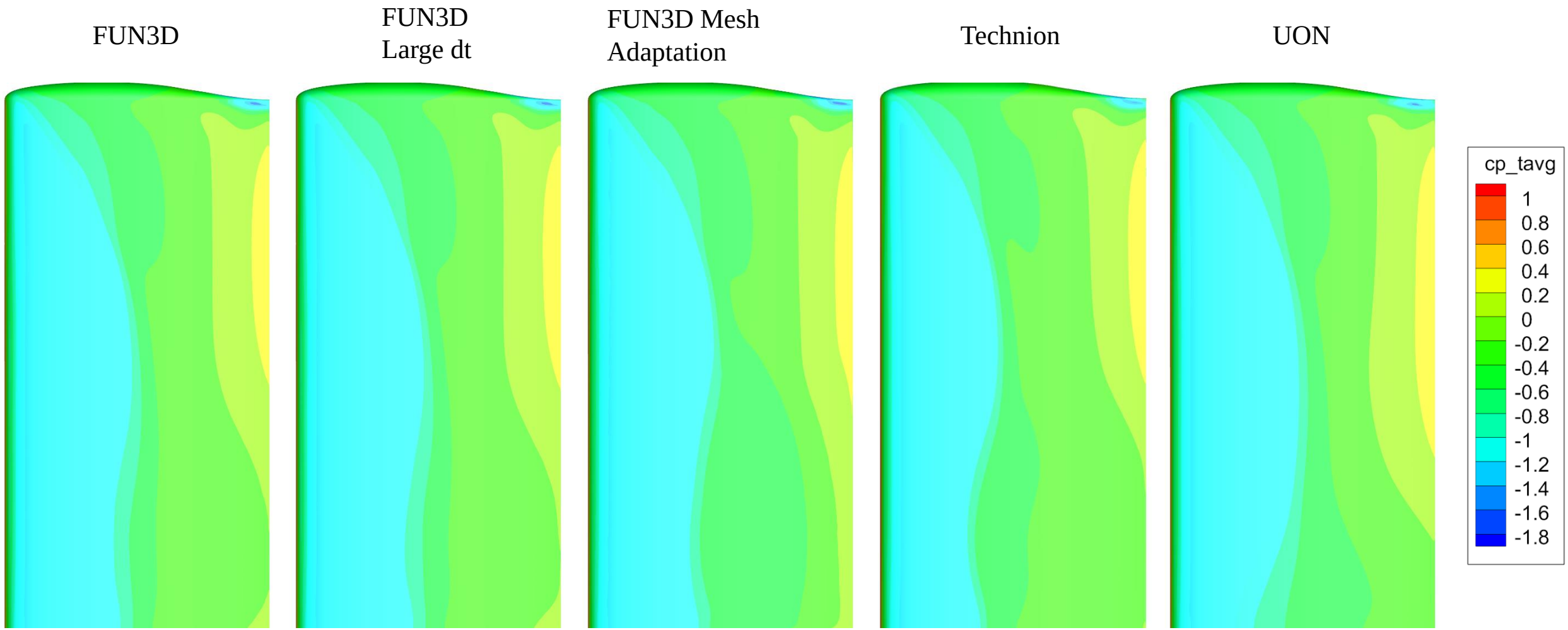




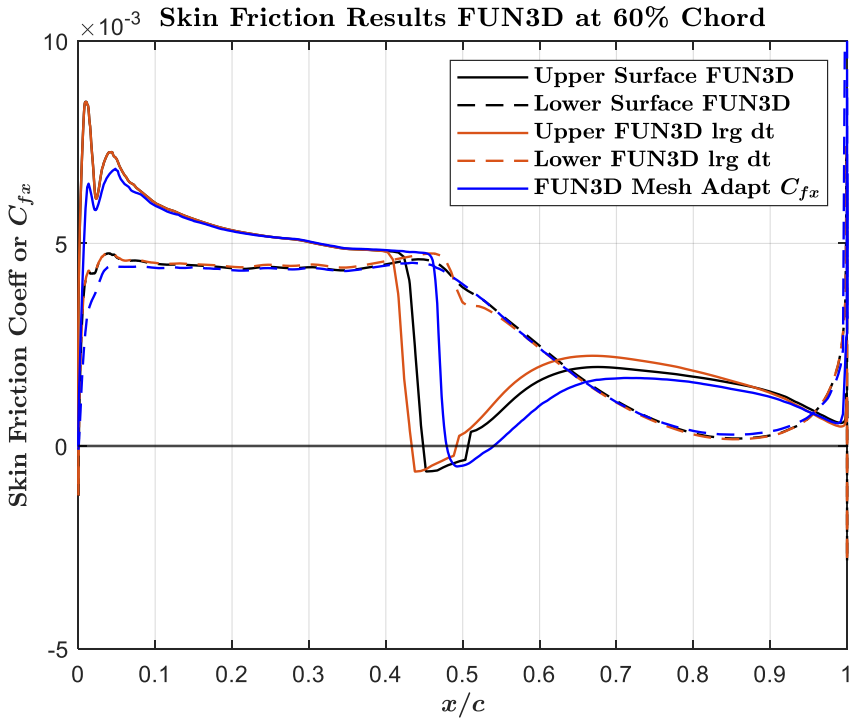
RMS Distribution

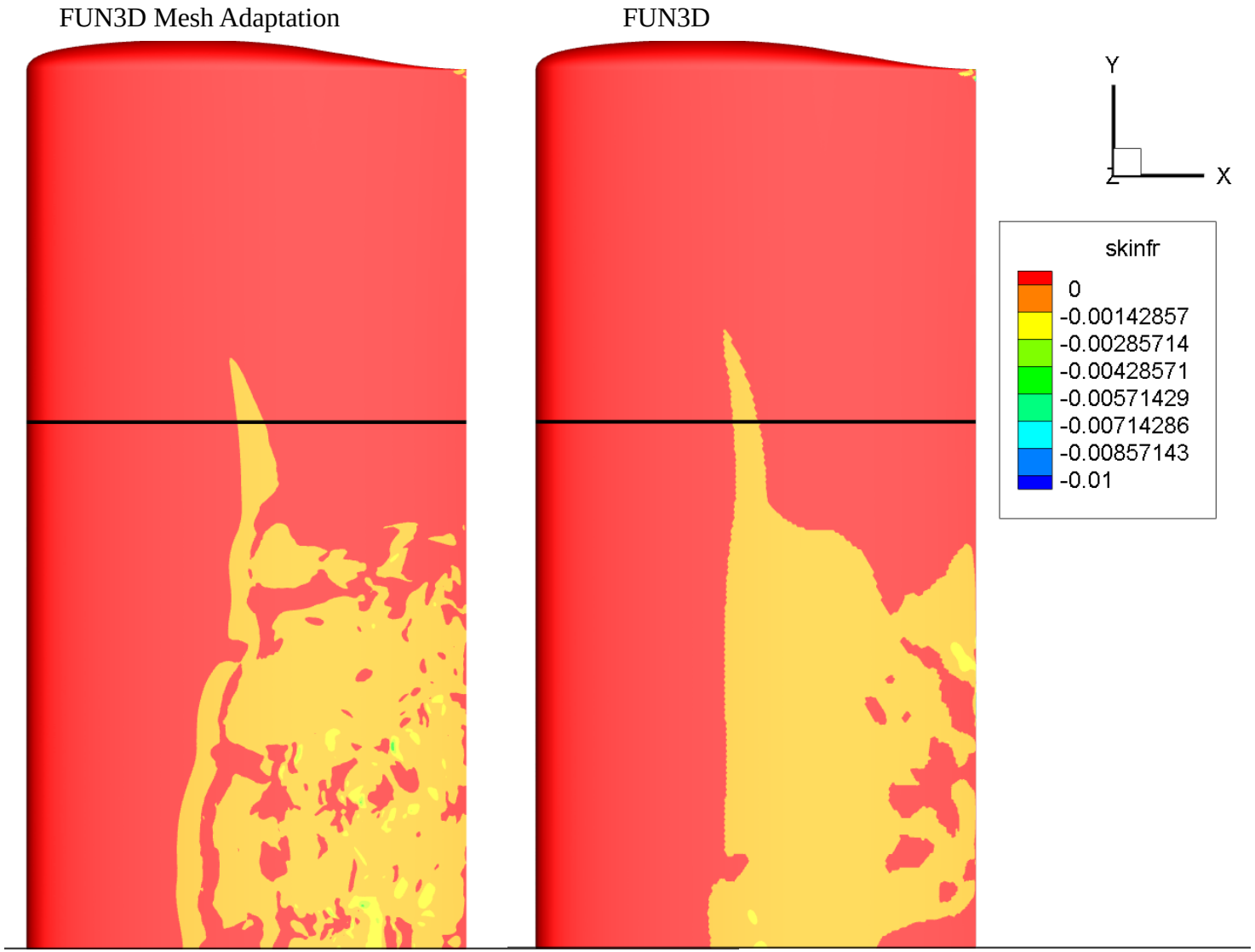


Average $C_{p,mean}$ Distribution



Backup Slides





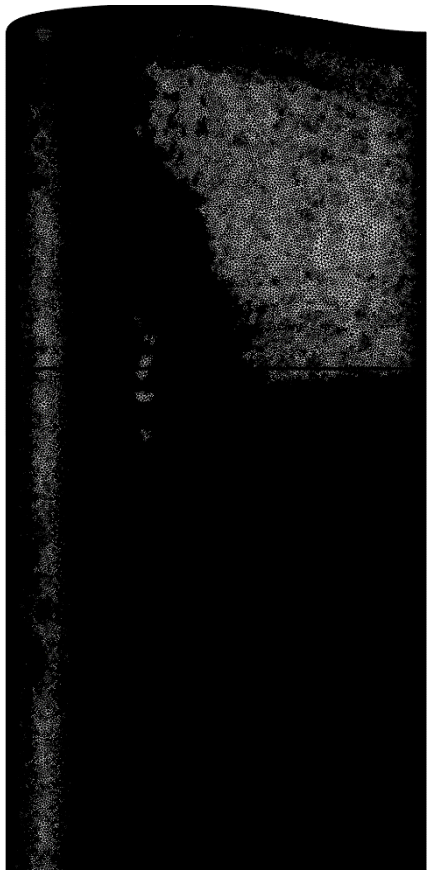
Summary and Conclusions

- All computational on the upper surface pressure compare well with experimental data. Pressures on the lower surface are under predicted when compared to experimental data.
- Spectral analysis reveals that frequencies near 5-6 Hz, 21 Hz and 30 Hz exist in all computational and experimental results with the 21 Hz magnitude peak being notably large
- Time histories reveal different oscillation magnitudes between experimental and computational results near the upper shock region, which may indicate differences in shock position, strength or shape
- RMS pressure values also appear to indicate a slightly different shock geometry between experiment and computation with computational results displaying a shock oscillation closer to the wing leading edge oscillating through a wider region and with a higher magnitude than experiment.

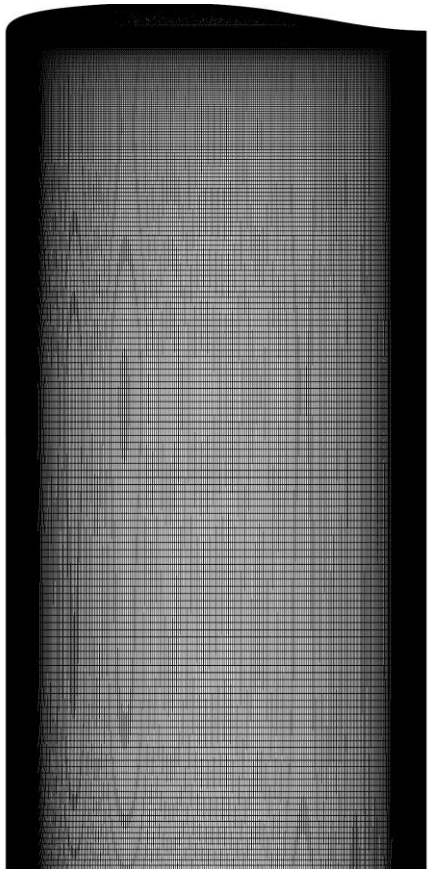
Mesh Comparisons

FUN3D,
FUN3D Large dt

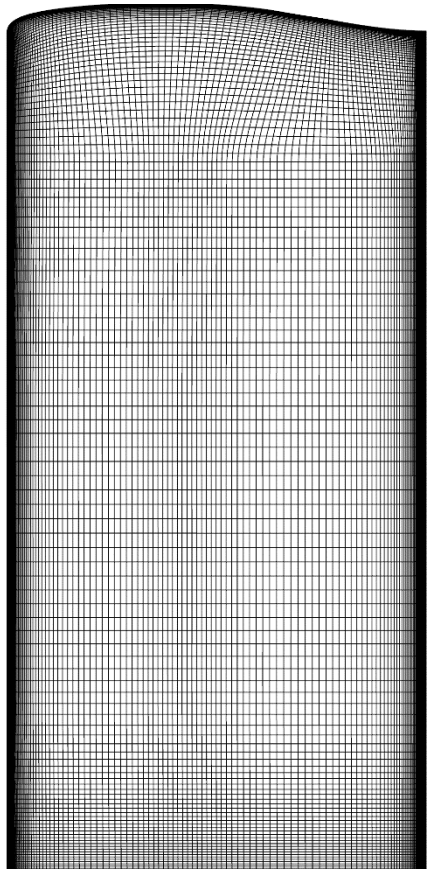
FUN3D Mesh
Adaptation



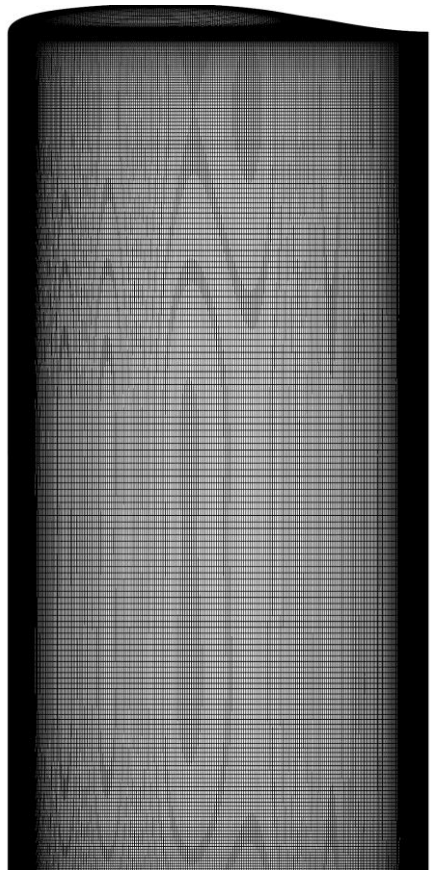
USAFA



Technion



UON



Backup Slides

Mesh Comparisons Lower Surface

FUN3D Vanilla, Vanilla Large dt

FUN3D Mesh Adaptation

USAFA

Technion

UON